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ABSTRACT

The basic purpose of the cooperative research project was to study the level of reasoning skills in junior high school students in Japan and the United States (grades 7, 8, and 9). This study examined the relationships among logical thinking skills, integrated process skills, and attitudes of junior high school students in North Carolina. Students' participation in out-of-school activities as well as teacher background variables were also studied. Nearly 40 teachers from 10 school districts and approximately 3,500 students from North Carolina provided data and a parallel study was simultaneously conducted in Japan. Instrumentation and results are discussed and include the topics of: (1) logical thinking (measuring concrete and formal thinking skills); (2) integrated process skills (examining five subscale skill areas); (3) attitudes (focusing on opinions toward science); (4) student participation (considering in-school and out-of-school activities); and (5) teacher background (obtaining data about teachers' education, experience, and teaching methods). Results in all tested areas are summarized and compared with findings of the Japanese counterparts. Suggestions are offered for improving student reasoning skills. (ML)

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A Study of the Logical Thinking Skills, Integrated Process Skills, and Attitudes of Junior High School Students in North Carolina

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Finally, the research team would like to thank the teachers and students who participated in the study. Nearly 40 teachers and approximately 3,500 students provided data for the research project.

Introduction to the Study

Formal schooling in all societies has several purposes: to transmit knowledge, societal norms and values, and vocational skills, to name a few. One of the Cardinal Principles of American education has been to help young people learn to think. In the area of science education, the concern for developing thinking skills is usually described as a concern for developing scientific thinking or reasoning abilities. (Too often, unfortunately, this has been greatly restricted to memorizing the steps in the scientific method.)

Terms such as thinking skills, scientific thinking, reasoning skills, cognitive development, critical thinking, and logical thinking are often used interchangably in the professional literature by people in different academic disciplines. Upon examination, those afore-mentioned terms contain similar elements such as the search for cause and effect, critical analysis, recognizing relationships, etc.

Japanese education, whose curriculum was modeled after American education in the late 1940's, has expressed growing concern for developing thinking skills in their students as well. Yet in both the United States and Japan, no large data base has been developed on the logical thinking abilities of students.

In the natural sciences, specifically, the basic science facts and concepts are being taught to most all students at the junior high and high school level in the United States and Japan--and even more systematically at the elementary school level in Japan. However, there is little evidence that skills in developing logical thinking and reasoning abilities are being taught to students in either society.

The basic purpose of the cooperative research project was to study the level of reasoning skills in junior high school students in Japan and the United States (grades 7, 8, and 9). Students in this age bracket are characteristically in the process of making the transition from concrete operational thinking to formal thought, according to the ideas of Piaget. However, Staver (1984), in his review of the literature on formal reasoning patterns, found that adolescents in junior high school through college often use pre-formal reasoning patterns in the classroom.

The formal thinking abilities studied in this project include the following: identifying and controlling variables, correlational logic, combinatorial logic, probabilistic logic, and proportional logic. It is also important to study these formal thinking abilities in relation to the development of integrated process skills and student achievement. According to Padilla (1983), the integrated process skills are involved when conducting experiments. A student must formulate a hypothesis, design an experiment, and make generalizations after collecting data. Padilla states that the ability to identify and control variables involves essentially the same steps as in conducting experiments. The data from Padilla's recent research (1983) showed

a correlation of .73 between test scores on tests of process skills and logical thinking abilities. This concept needs to be studied further in an effort to help understand this relationship in greater detail. In this relationship, it is not known whether the process skills affect the thinking abilities or vice versa.

In addition, this study attempted to assess the relationship between the reasoning skills, integrated process skills, science-related activities, and attitudes of junior high students. Knowledge of these relationships could ultimately lead to a better understanding of the learning needs of students and the teaching strategies necessary to meet these needs. Certainly, teachers will need to develop and implement activity-based curriculum which foster student achievement, critical thinking, positive attitudes, and process skill proficiency.

Design of the Study

The main purpose of this study was to assess the relationships between the logical thinking skills, integrated process skills, and attitudes of junior high school students in North Carolina. In addition, the students' participation in a variety of school and out-of-school activities was studied, as well as a number of factors related to the teachers of these students. The study was conducted during the 1984-85 school year. The plans for the research began in February 1983 in Japan, during a meeting between Dr. Takemura and Dr. Mattheis. Joint research proposals were subsequently submitted to the National Science Foundation (U.S.) and the Society for the Promotion of Science (Japan) during March 1983. The funding for this project was received in March 1984, and the U.S. team of Dr. Charles R. Coble, Dean, School of Education, East Carolina University; Dr. William E. Spooner, consultant in science, North Carolina State Department of Public Instruction; and Dr. Floyd E. Mattheis, Director, Science/Math Education Center, East Carolina University, made plans to visit Japan to discuss the parallel research projects. This team visited Japan for three weeks during May 1984 to discuss every aspect of the project at great length with the Japanese research team.

In June 1984, a group of ten science coordinators was invited to a planning meeting in Raleigh to discuss whether they wanted to participate in the proposed research project. All of the science coordinators agreed to participate. A list of the science coordinators and the teachers who participated is included in the Appendix.

The basic plan was to distribute the instruments during October 1984 so the testing could be carried out during the first three weeks of November 1984. The scoring of the tests would be done in December so that the analysis of the data could be carried out in January and February 1985 with a preliminary report prepared by the end of March 1985. The Japanese research team translated the tests into Japanese and set up a similar testing schedule for November 1984.

The Research Questions

1. Is there a relationship between student attitudes and measures of logical thinking?

2. Is there a relationship between student attitudes and measures of science process skills?

3. Is there a relationship between student measures of logical thinking and their science process skills?

4. Is there a relationship between student activities and measures of student attitudes toward science?

5. Is there a relationship between student activities and integrated process skills?

6. Is there a relationship between student activities and logical thinking skills?

The Instruments Used in the Study

1. The Group Assessment of Logical Thinking (GALT) (Roadrangka, Yeany, and Padilla). The GALT test was revised in 1983 to a 12-item test that could be divided into six subscales involving data from two test items. The correlation between test scores from the original test and the shortened test was very high, so it was decided to use the short version. A copy of this test is included in the Appendix. The test measures six logical operations: conservation (items 1, 2); proportional reasoning (items 3, 4); controlling variables (items 5, 6); combinatorial reasoning (items 11, 12); probabilistic reasoning (items 7, 8); and correlational reasoning (items 9, 10).

   The test uses a double multiple choice format for presenting options for answers as well as the justification or reason for that answer. The test uses pictorial representations of real objects in all test items and is suitable for students reading at the sixth grade level or higher. Another advantage of the test is that it can be administered in one class period to a large group by individuals who serve simply as proctors. The GALT test has sufficient reliability (.85) and validity (.80) to distinguish between groups of students at concrete, transitional, and formal stages of development (Roadrangka, Yeany, and Padilla, NARST Paper, 1983).

2. The Test of Integrated Process Skills (TIPS II) (Burns, Wise, and Okey). The TIPS II test was developed in 1983 as an additional version of an earlier TIPS test. The test consists of 36 items that are designed to measure five process skills: identifying variables (items 1, 3, 13, 14, 15, 18, 19, 20, 30, 31, 32, 36); identifying and stating hypotheses (items 4, 6, 8, 12, 16, 17, 27, 29, 35); operationally defining (items 2, 7, 22, 23, 26, 33); designing investigations (items 10, 21, 24); and graphing and interpreting data (items 5, 9, 11, 25, 28, 34). The total

test reliability was measured at .86, and the content validity was taken from the opinions of six experienced science educators. This test can be given to a large group of students during one class period. Students typically take from 25-50 minutes to finish the test. There is a high correlation (.71) between scores on the TIPS II test and the GALT test (Burns, Wise, and Okey, NARST Paper, 1983). A copy of the TIPS II test is included in the Appendix.

3. Attitudes Toward Science Scales. This scale was adapted by Spooner from a scale developed by Lewis R. Akin to measure student attitudes toward the study of mathematics. Dr. Spooner modified the items to reflect attitudes toward science instead of mathematics. The modified instrument has a very high reliability (.95)and seemed to be appropriate for use in this research project. A copy of this instrument is included in the Appendix. The 20-item scale was scored on a 1-5 Likert type test so that the highest possible score was 100 and the lowest possible score was 20.

4. Student Questionnaire. This instrument was developed with the leadership of the Japanese research team. The Japanese instrument was modified to provide items more relevant to the experiences of students in the U.S. Twenty-nine items were used in the questionnaire, and a 3-2-1 weighting was given to each item. The in-school and out-of-school activities were scored separately. The highest possible score in each case was 87, and the lowest score was 29. A total score was calculated for in-school and out-of-school activities. A copy of this instrument is included in the Appendix.

5. Teacher Questionnaire. The questionnaire given to the teachers was developed by the U.S. team in cooperation with the Japanese team. The wording of the items was changed to be more appropriate for the North Carolina teachers who participated in the project. It was not possible to calculate a total score for this questionnaire. A copy of this instrument is included in the Appendix. The purpose of the questionnaire was to obtain data about the education, experience, and teaching methods of the teachers.

The Study Group

The group participating in this study included 40 teachers from 10 school districts in North Carolina and approximately 3,500 students in grades 7, 8, and 9. In the analysis of the data, only the students who had completed all four instruments were included (3,291). A complete list of the school districts and teachers is given in the Appendix. A summary of the student demographic variables is given in Table 1.

An effort was made to obtain data from a typical cross-section of North Carolina students in grades 7, 8, and 9. Figure 1 shows the distribution of tests from which the student sample was drawn.

TABLE 1
Summary Statistics
Test Centers = 10

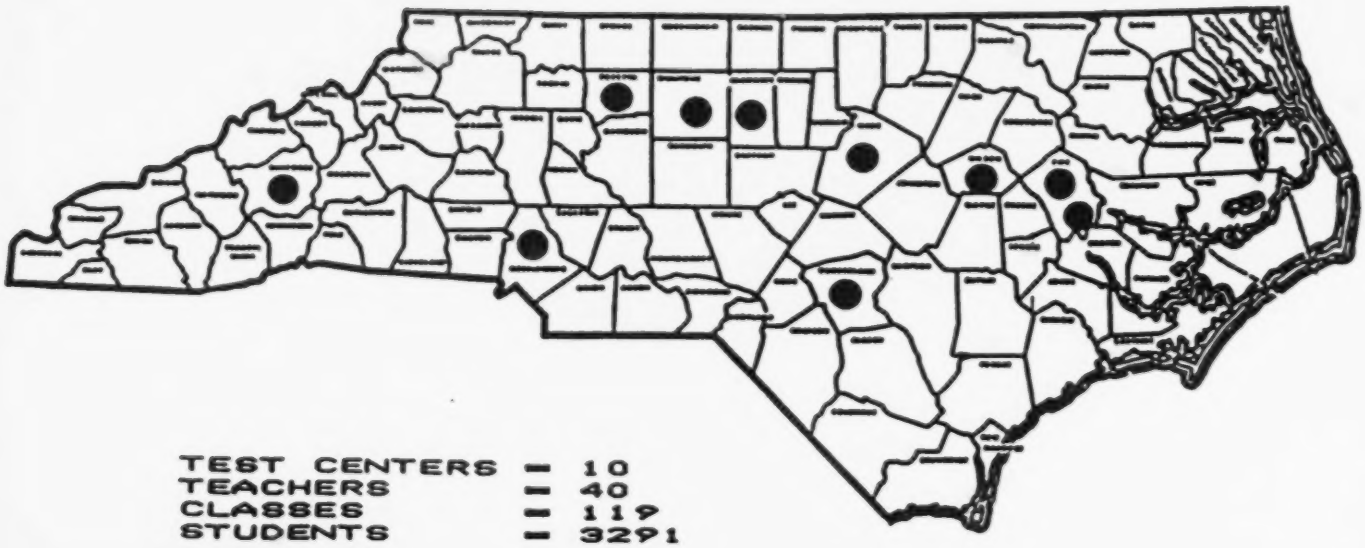
		7	8	9
Teachers		13	16	12
Classes		40	49	30
Students		805 (27.9%)	1261 (43.7%)	818 (28.4%)
Sex	male	399 (49.65%)	625 (49.75%)	380 (46.4%)
	female	406 (50.4%)	636 (50.4%)	438 (53.5%)
Age-Years		12.25	13.31	14.23
	male	12.36	13.41	14.29
	female	12.18	13.19	14.16

FIGURE 1

NORTH CAROLINA / JAPAN PROJECT

1984-85

TEST CENTERS



Collection of the Data

The collection of data involved scheduling two class periods for each class of students to take the GALT, TIPS II, Student Questionnaire, and the Attitude Scale. During the summer 1984 meeting with the science coordinators, it was decided that:

1. the tests would be given during the first two weeks in November 1984.

2. teachers would give the instruments to all sections of their science or mathematics classes.

3. the GALT and the questionnaire would be given during a 50-minute class period, and the TIPS II and the attitude scale would be given during a second class period (on another day).

4. the two testing sessions would be on different weeks, if possible.

5. the teachers would serve as proctors and return all answer sheets and tests to the science coordinators.

6. identification numbers would be assigned to all students and put on the instruments instead of names.

7. answer sheets and questionnaires would be returned to the science coordinators and teachers as well as an analysis of the data for their students during the spring of 1985.

A massive printing effort was undertaken to print 6,000 copies of each instrument and answer sheet with the help of Dr. Charles Coble, Dean of ECU's School of Education, and his staff. These tests and answer sheets were distributed to the science coordinators during September and October 1984.

In late November, the tests and answer sheets were sent to the Science/Math Education Center at ECU. During December and early January, the monumental task of transposing all of the data from four instruments (GALT, TIPS II, Attitude Scale, and Student Questionnaire) to a single machine-scorable answer sheet was carried out by a team of graduate students in the Science Education Department. It took more than 1,000 hours of work to carry out this aspect of the project. Upon completion of this work, the answer sheets (machine-scorable) were sent to Dr. Spooner, SDPI, for the data analysis.

Duration of the Study

An outline of the time frame for the various aspects of the project is given below:

February 1983 — Tokyo, Japan - Preliminary plans for research proposal

March 1983	Proposals submitted to NSF and JSPS
March 1984	Projects funded by NSF and JSPS
May 1984	Planning sessions at Hiroshima University
June 1984	Conference for selected science coordinators in Raleigh
September 1984	Planning sessions in North Carolina with Japanese team; Printing of 6,000 tests, scales, questionnaires, and answer sheets
October 1984	Final plans for testing and distribution of tests to coordinators and teachers
November 1984	Administration of four instruments to each student and completion of Teacher Questionnaires; all tests, answer sheets, etc. sent to ECU
December 1984 - January 1985	Transpose all data to machine-scorable answer sheets, ECU
January - April 1985	Analysis of data and preparation of preliminary report, SDPI
April 1985	Submission of proposal to NSF for cooperative seminar in September 1986
May 1985	Conference at Hiroshima University
June - August 1985	Writing of final report, ECU and SDPI
September 1985	Final conference in North Carolina with Japanese team and meeting with NSF officials to discuss project
October 1985 - May 1986	Submission of final report to NSF and planning for cooperative seminar

Analysis of the Data

Data for student instruments used in this project was processed for computer analysis from optical-scan score sheets. The Statistical Analysis Systems (SAS) program was used for descriptive statistics and hypothesis testing with the exception of internal consistency measures for Cronback's Alpha. These coefficients were hand calculated. Graphic representation of data was achieved with the software package SNAP Graph, produced by Celcor, Inc., of Raleigh, N.C. Initial data analysis for the 3,291 student sample was examined using the SAS PROC MEANS and PROC PRINT procedures. Student data which was incomplete in regards to various instruments were not included in

the data analysis. Subject data which was omitted on variables such as sex and grade level were dropped from subsequent analyses which dealt with those variables.

Research hypotheses on the relationships between various variables were tested with a SAS PROC CORR procedure. This method provided the Pearson Product Moment correlation coefficients and significance levels.

Descriptive Statistics and Results

The results of the analysis of the Group Assessment of Logical Thinking (GALT), Integrated Process Skills Test II (TIPS II), Science Attitude Scale (modified from the Lewis R. Akin Revised Mathematics Scale with permission from the author), and the Student Questionnaire (in-school and out-of-school) are provided in this section.

The mean scores for all instruments by grade, sex, and grade/sex are shown in Table 2.

TABLE 2

NORTH CAROLINA - JAPAN PROJECT 1984-85

North Carolina Mean Scores

n = 3291

	N	ATTITUDE	GALT	TIPS	(school) QUESTA	(home) QUESTB
Maximum Score		100	12	36	87	87
TOTAL	3139	69.98	3.67	17.34	39.95	45.52
BY GRADE						
7	943	71.30	3.17	16.06	40.89	47.57
8	1358	69.21	3.69	16.98	39.10	44.20
9	964	69.92	4.12	19.12	40.25	45.37
BY SEX						
F	1480	69.89	3.51	17.69	40.32	45.53
M	1408	71.60	3.95	17.36	39.96	46.84
BY GRADE BY SEX						
7F	406	70.54	2.92	15.94	41.24	47.04
7M	403	72.54	3.42	16.11	41.11	48.60
8F	638	67.88	3.66	17.57	39.48	43.29
8M	624	70.75	3.87	16.69	38.75	45.20
9F	439	68.84	3.95	19.56	41.41	44.80
9M	381	71.51	4.58	19.30	39.92	46.74

Group Assessment of Logical Thinking (GALT)

The Group Assessment of Logical Thinking (GALT) test consists of 12 questions used to measure concrete and formal thinking skills. The test is divided into six subscales (two items each) that measure conservation (mass and volume), proportional reasoning, control of variables, probability, correlational reasoning, and combinatorial reasoning.

Raw scores ranged from 0-12, with a mean score of 3.67 for all grades. The standard deviation for all grades was 2.42. The mean score for seventh graders was 3.17, with an increase to 3.69 for eighth graders, and another increase to 4.12 for ninth graders. At each grade level, male students scored higher than female students. The mean score for males and females was 3.95 and 3.51 respectively for all grades. Seventh grade males scored 3.42 compared to a score of 2.92 for females. At the eighth grade level, males scored 3.87 compared to 3.66 for females. The largest difference in scores between males and females was observed at the ninth grade level. Males scored 4.58 compared to a score of 3.95 for females. This difference is shown in Figure 2. Males and females show gains in scores on the GALT test with increasing grades. The difference between males' and females' scores within grade levels is not considered to be of practical significance. However, significant gains in overall mean scores were made between the seventh and ninth grades. The relative gains are illustrated in Figure 3.

FIGURE 2

GALT SCORES BY SEX

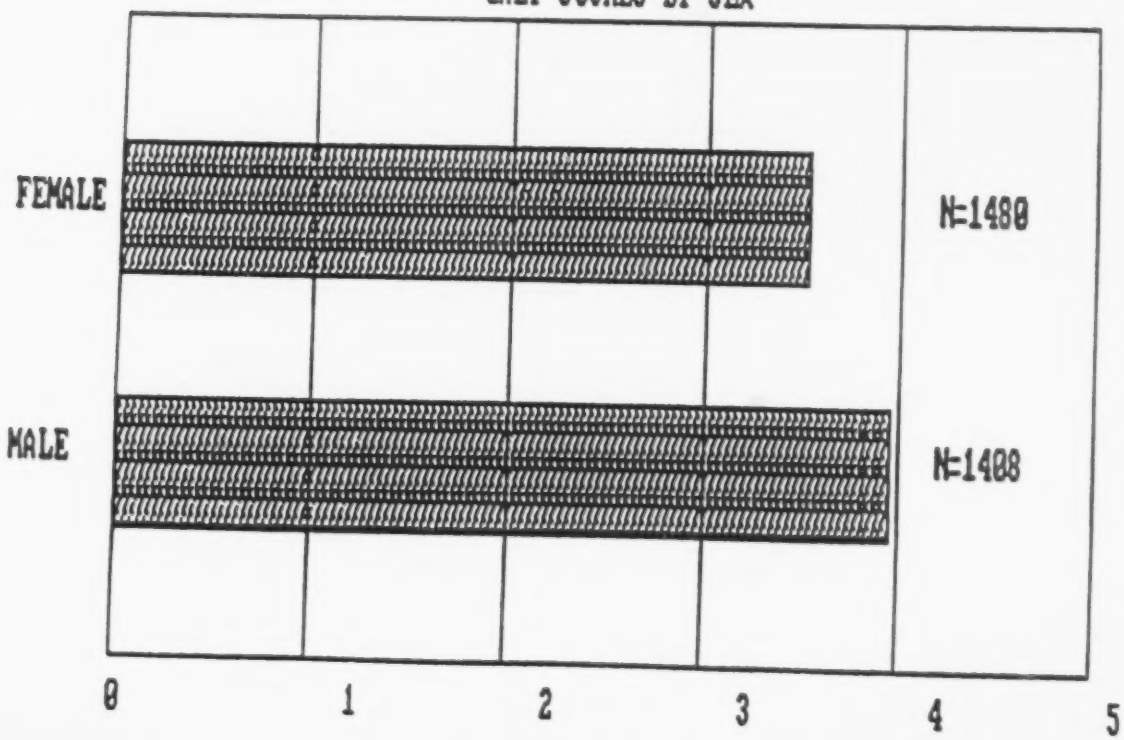
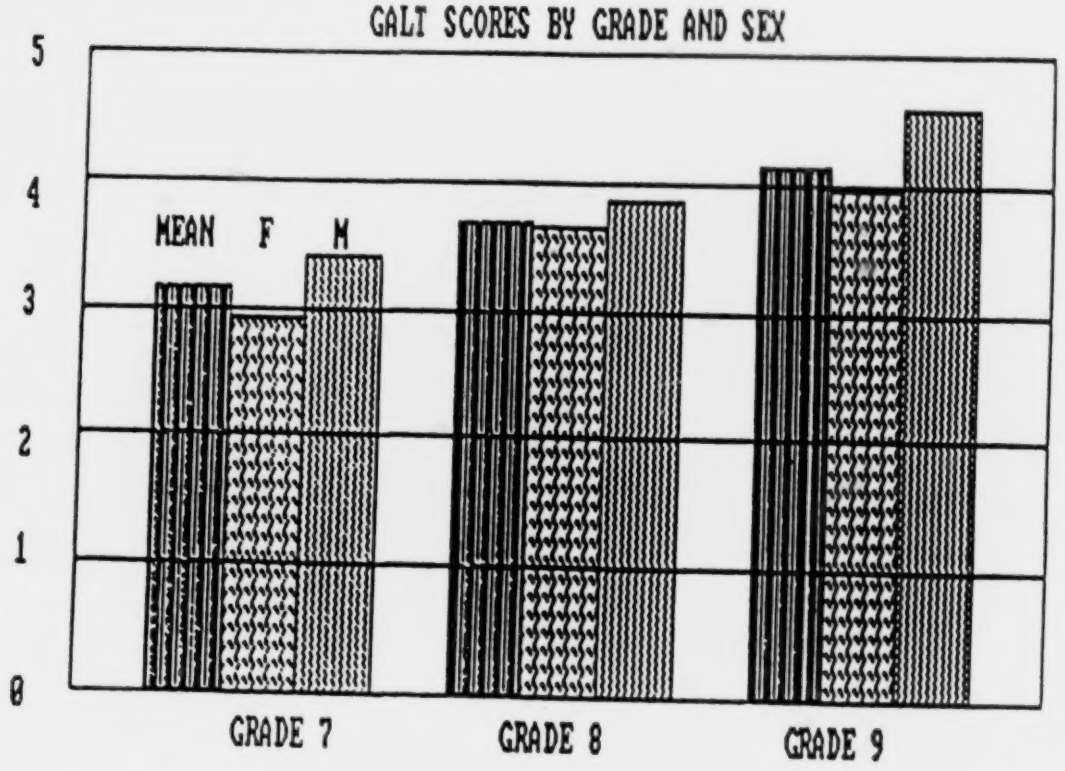


FIGURE 3



The subscales on the GALT test measure students' abilities to deal with the tasks of conservation, proportional reasoning, control of variables, probability, correlational and combinatorial reasoning. Each subscale consists of two questions. The mean scores and standard deviations for each question are shown on Table 3.

The highest scores were observed on questions 1 and 2, which measure conservation skills in mass and volume. The higher scores on conservation tasks are expected according to theory. Most students in the middle grades should have mastered these skills. The results also show that students score higher on conservation of mass. The mean score was .77 as compared to the mean score of .45 for conservation of volume. This also reflects expected outcomes based on theory.

The formal operational skills present a much more difficult task for the middle grades student, as indicated by mean scores on Table 3.

TABLE 3

Descriptive Statistics for the GALT (NC mean scores by items)

	Item Number	N	Mean (range 0 - 1)	S.D.
1	Conservation (mass)	3291	.77	.42
2	Conservation (volumn)	3291	.45	.49
3	Proportional	3291	.10	.30
4	Proportional	3291	.23	.42
5	Controlling Variables	3291	.24	.43
6	Controlling Variables	3291	.30	.45
7	Probability	3291	.16	.36
8	Probability	3291	.18	.38
9	Correlational	3291	.13	.34
10	Correlational	3291	.04	.19
11	Combinatorial	3291	.72	.45
12	Combinatorial	3291	.35	.48
	GALT (all items)	3291	3.67	2.42

The most difficult formal operational skill found in this study involves correlational reasoning. Items 9 and 10 received scores of .13 and .04 respectively. The mean score for the two items was .17. This is illustrated in Table 4. The average of the two correlational reasoning tasks for grades 7, 8, and 9 are .15, .19, and .17 respectively. No significant gain is observed with the progression of grade levels.

Scores on proportional and probabilistic reasoning tasks received higher mean scores than those observed on correlational reasoning tasks. The mean scores for proportional and probabilistic reasoning tasks were .33 and .34 respectively. The mean scores for seventh, eighth, and ninth grade levels on proportional reasoning were .24, .35, and .42 respectively. Likewise, scores on probabilistic reasoning were .20, .36, and .43. The tasks of controlling variables received higher scores than the preceding two tasks with a mean score of .54. Means at the seventh, eighth, and ninth grade levels were .45, .53, and .64 respectively.

Table 4

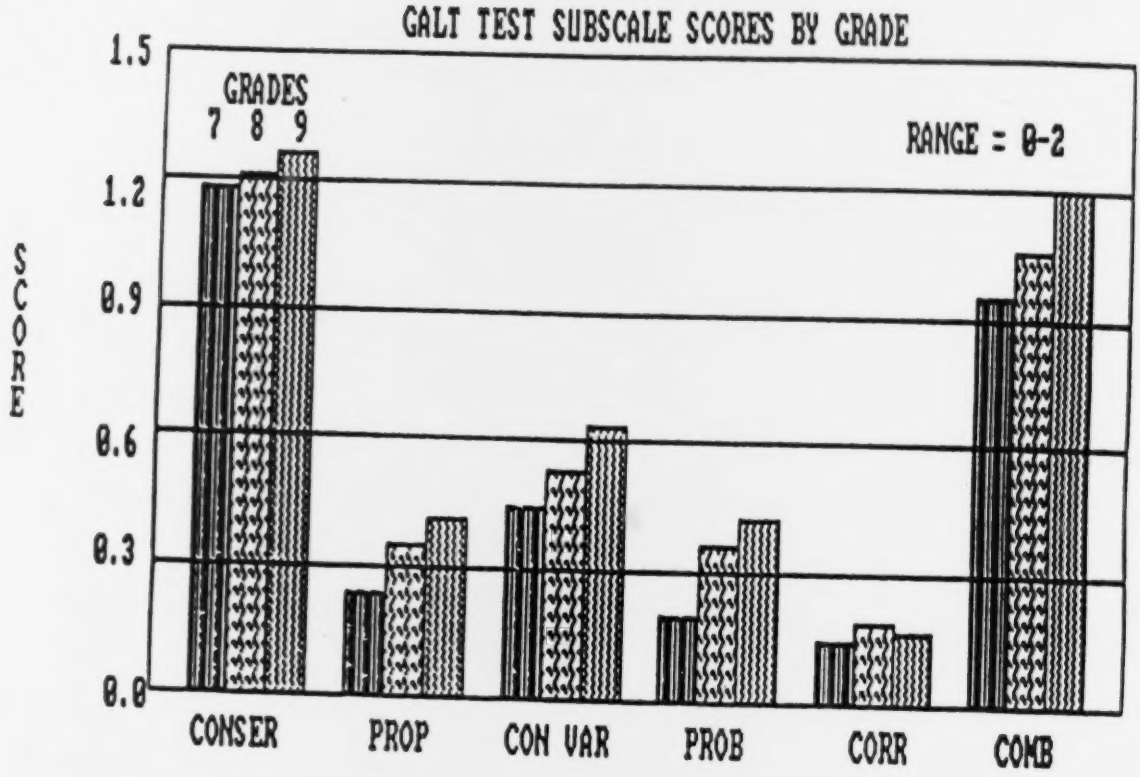
INSTRUMENT RELIABILITY

Internal Consistency
measured by Cronbach's alpha

		N
Science Attitude Scale		
Total (7, 8, 9)	$\alpha = .95$	3291
grade 7	$\alpha = .96$	943
grade 8	$\alpha = .95$	1356
grade 9	$\alpha = .95$	964
GALT		
Total (7, 8, 9)	$\alpha = .77$	-
grade 7	$\alpha = .68$	-
female	$\alpha = .63$	406
male	$\alpha = .74$	403
grade 8	$\alpha = .71$	-
female	$\alpha = .70$	438
male	$\alpha = .71$	424
grade 9	$\alpha = .77$	-
female	$\alpha = .73$	439
male	$\alpha = .79$	381
TIPS		
Total (7, 8, 9)	$\alpha = .82$	-
grade 7	$\alpha = .81$	-
grade 8	$\alpha = .81$	-
grade 9	$\alpha = .82$	-
QUESTIONNAIRE A Total (7, 8, 9)	$\alpha = .90$	-
QUESTIONNAIRE B Total (7, 8, 9)	$\alpha = .91$	-

The highest scores on formal operational tasks were observed for combinatorial reasoning. The mean score for the two items was 1.07 with seventh, eighth, and ninth grade level scores of .95, 1.05, and 1.20 respectively. The differences in scores on the different tasks by grade levels are well illustrated in Figure 4.

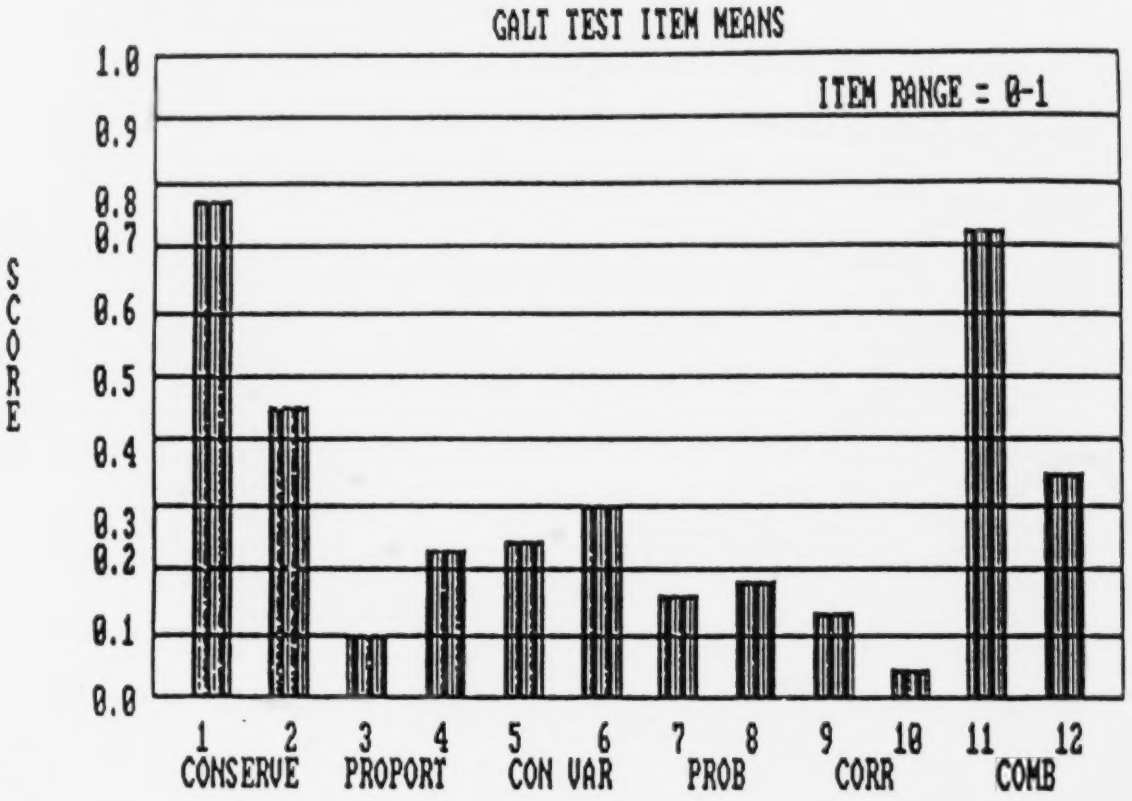
FIGURE 4



The high score on combinatorial reasoning and the low score on correlational reasoning are not fully understood. A test item factor may be a variable affecting these results. Cronback's alpha for the GALT test was determined to be .77 for all grades. The coefficient varied between grade levels and between sex between .63 and .79. Table 4 gives the internal consistency measures for all instruments. Other instruments used in this project show high consistency with reliability coefficiency between grade levels. The problem with item difficulty is more apparent in Figure 5. Item 10 on correlational reasoning was most difficult with less than 5% correct response on the average. Item 3 on proportional reasoning also received a low score. However, the lower item numbers on the GALT test must also be considered a factor with respect to reliability.

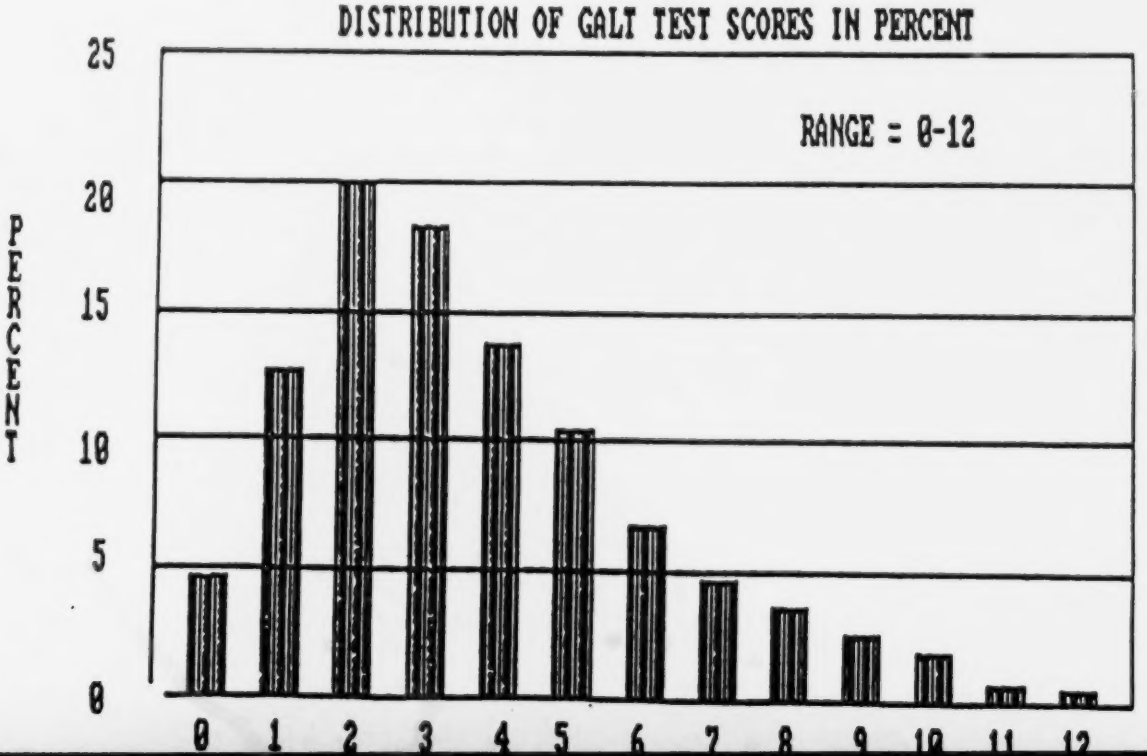
A progression of increasing scores is observed as the student grade level increases from the seventh to the ninth grade. This progression is observed on all subscales with the exception of correlational reasoning. Figure 5 illustrates the subscale item scores. Differences in scores were observed between the two items of each subscale with the exception of items 7 and 8 on probabilistic reasoning. Item 10, on correlational reasoning, had the lowest mean, receiving a score of .04 out of a possible 1.0.

FIGURE 5



The distribution of GALT test scores in percent is shown in Figure 6. The distribution is negatively skewed with a mean of 3.67. It appears that many

FIGURE 6



subjects had difficulty with the GALT test. Approximately 5% of the subjects did not get the correct answer for any of the 12 test items. Thirteen percent of the subjects only got one item correct.

The problem middle grades students have with formal reasoning tests is further illustrated when the GALT test scores are classified according to the developmental stages of concrete, transitional, and formal. The classification of scores for all subjects, grades seven through nine, reveals that 69 percent are functioning at the concrete operational level. While 22% are considered at the transitional stage, only 9% of the subjects are functioning at the formal operational stage (Table 5).

TABLE 5

Frequency Distribution of GALT Scores and Developmental Stages (grades 7-9)

Score	Frequency	Percent	Developmental Stage
0	155	4.70	
1	419	12.73	
2	657	19.96	CONCRETE
3	599	18.20	69.25%
4	450	13.67	
5	344	10.45	
6	223	6.77	TRANSITIONAL
7	152	4.61	21.83%
8	119	3.61	
9	83	2.52	
10	64	1.94	FORMAL
11	23	.70	9.27%
12	3	.50	
MEAN = 3.67	3291	100.00	

When developmental stages are examined by grade level, obvious progressions in categories are observed. The highest percentage of concrete operational functioning is observed at the seventh grade level with 78.47 percent in this category. Furthermore, only 4.85 percent of seventh grade students are functioning at the formal operational level. These results are shown in Table 6.

TABLE 6

Frequency Distribution of GALT Scores and Developmental Stages (grade 7)

Score	Freguency	Percent	Developmental Stage
0	59	6.26	
1	138	14.63	
2	225	23.86	CONCRETE
3	171	18.13	78.47%
4	147	15.59	
5	86	9.12	
6	43	4.56	TRANSITIONAL
7	28	2.97	16.65%
8	21	2.23	
9	10	1.06	
10	10	1.06	FORMAL
11	4	.40	4.85%
12	1	.10	
MEAN = 3.17	943	100.00	

At the eighth grade level, the percentage of students at the concrete operational stage lowers to 69%. More students are observed to be functioning at the transitional and formal stages. The percentage of students at the formal stage doubles (9.5%). These results are shown in Table 7.

TABLE 7

Frequency Distribution of GALT Scores and Developmental Stages (grade 8)

Score	Frequency	Percent	Developmental Stage
0	59	4.35	
1	169	12.45	
2	258	19.00	CONCRETE
3	263	19.37	69.01%
4	188	13.84	
5	140	10.31	
6	98	7.22	TRANSITIONAL
7	63	4.64	22.17%
8	52	3.83	
9	39	2.87	
10	22	1.62	FORMAL
11	6	.44	9.50%
12	1	.74	
MEAN = 3.69	1358	100.00	

A further reduction in percentage of students at the concrete operational stage is observed at the ninth grade level. The percentage of students at the transitional and formal operational stages increases. At the ninth grade level, we find that approximately 13% of the subjects are functioning at the formal operational level. These results are shown in Table 8.

TABLE 8

Frequency Distribution of GALT Scores and Developmental Stages (grade 9)

Score	Frequency	Percent	Developmental Stage
0	35	3.63	
1	110	11.41	
2	169	17.53	CONCRETE
3	159	16.50	60.79%
4	113	11.72	
5	116	12.03	
6	79	8.20	TRANSITIONAL
7	60	6.22	26.45%
8	45	4.69	
9	33	3.42	
10	31	3.22	FORMAL
11	13	1.35	12.78%
12	1	.10	
MEAN = 4.12	964	100.00	

An overall progression to higher thinking levels is observed as students move to the next grade level. These results are shown in Figures 7 and 8. Whether this observation is a function of age or educational experience is not clear. The investigators in this study were surprised to find the low percentages of students functioning at the formal operational level and furthermore believe that gains in formal reasoning scores are possible with improved instruction in science at the elementary school level.

FIGURE 7

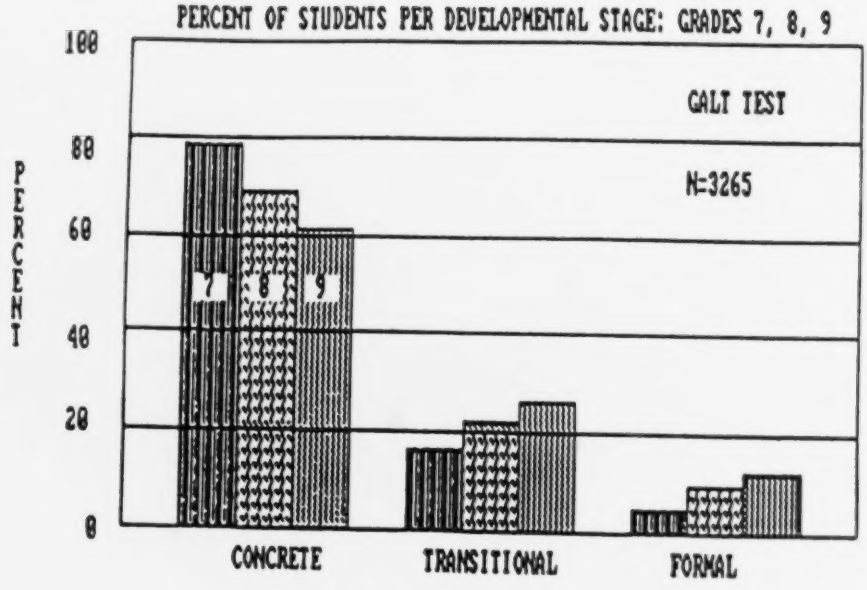
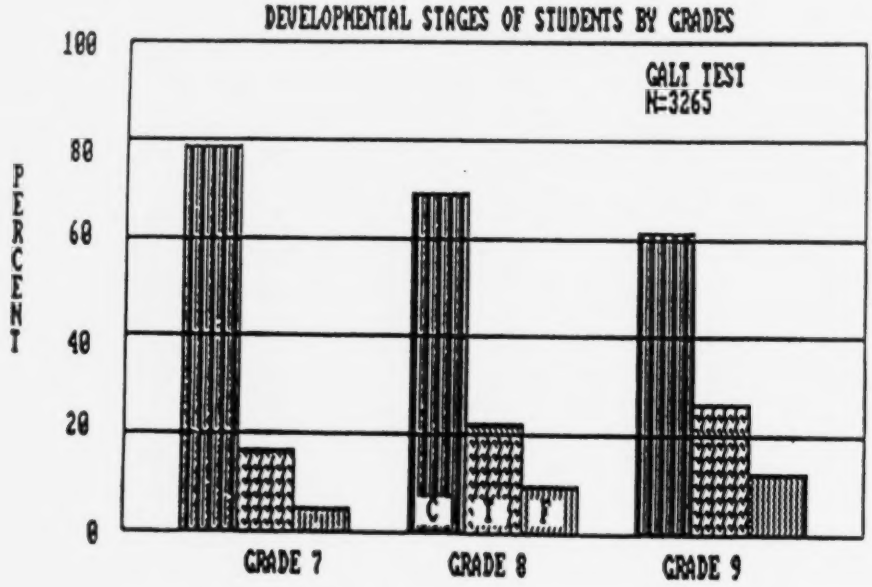


FIGURE 8



Differences in the percentage of students at each developmental stage were also observed between males and females. More females were observed to be at the concrete operational stage. This observation is found across grade levels. The difference is less than 7 percent. The smallest difference between males and females was at the eighth grade level, with an observed difference of .04%.

At the transitional stage, the differences between sexes were less obvious. There were fewer females than males at the transitional stage in the seventh grade level. This trend reversed at the eighth and ninth grade levels, with males showing the lower percentage at this stage.

The most obvious differences between male and female students were observed at the formal operational stage. A higher percentage of males were observed at each grade level. The largest difference was found at the ninth grade level, with the male and female percentages of 19.2 and 9.5 respectively. The smallest difference was found at the eighth grade level with a 2.1% higher percentage for the male subject. These results are shown in Table 9.

TABLE 9

Frequency Distribution in percent of GALT Scores and Developmental Stages by Grade and Sex

Score	grade 7		grade 8		grade 9	
(# correct)	F	M	F	M	F	M
0	5.9	7.2	4.4	3.4	3.9	2.9
1	18.7	12.2	11.4	11.9	11.2	9.4
2	24.9	22.1	20.2	16.7	17.8	15.7
3	17.2	16.4	19.9	19.6	16.9	15.7
4	14.5	17.9	12.4	16.3	12.3	11.5
CONCRETE %	(82.1)	(75.8)	(68.3)	(67.9)	(62.1)	(55.2)
5	8.4	9.2	12.5	9.1	14.1	11.8
6	4.9	4.0	7.2	7.5	8.2	7.4
7	2.5	4.0	4.1	5.4	6.1	4.0
TRANSITIONAL %	(16.0)	(17.2)	(23.8)	(22.0)	(28.4)	(25.4)
8	1.5	2.2	3.0	4.8	3.4	7.1
9	.7	1.7	2.7	3.0	3.6	4.2
10	.5	2.8	1.7	1.4	2.0	4.7
11	0.0	1.8	.3	.4	.5	2.9
12	0.0	.2	.2	0.0	0.0	.3
FORMAL %	(2.7)	(7.1)	(7.9)	(10.0)	(9.5)	(19.2)
GALT MEANS	2.92	3.42	3.44	3.87	3.95	4.58

Integrated Process Skills Test II (TIPS II)

The Integrated Process Skills Test II (TIPS II) is designed to measure students' understanding of science process skills. A student component in process skills can take information and use it to produce solutions to problems. There are 36 items in the test, which are divided among these five areas: identifying variables, operationally defining, identifying and stating hypotheses, designing investigations, and graphing and interpreting data.

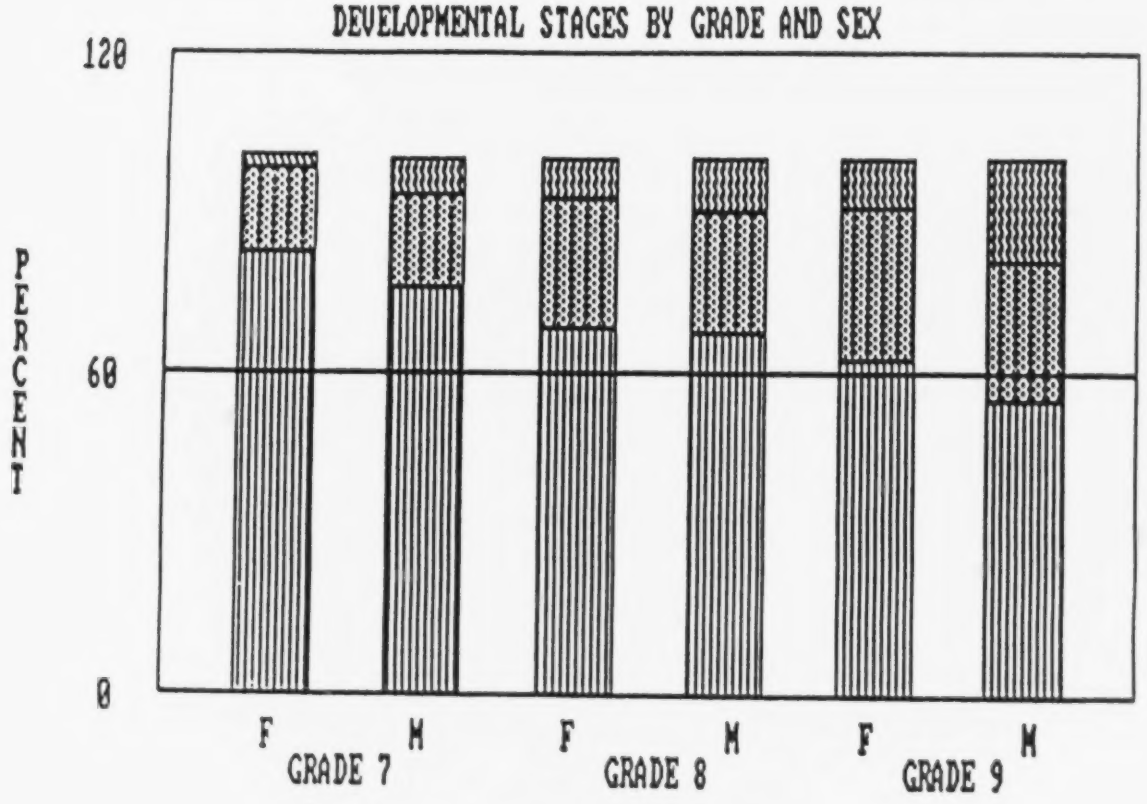
Item means and standard deviations for the TIPS test are shown in Table 10. The mean scores by item are also illustrated in Figure 9. The more

TABLE 10

TIPS Item Means

Item #	Mean	SD
1	.77	.42
2	.55	.49
3	.80	.40
4	.68	.47
5	.29	.45
6	.46	.50
7	.58	.49
8	.42	.49
9	.73	.44
10	.80	.40
11	.73	.44
12	.56	.12
13	.37	.48
14	.47	.49
15	.30	.46
16	.39	.49
17	.67	.47
18	.27	.44
19	.48	.50
20	.27	.44
21	.54	.50
22	.55	.50
23	.43	.50
24	.55	.50
25	.44	.50
26	.63	.48
27	.10	.31
28	.58	.49
29	.52	.50
30	.23	.42
31	.38	.49
32	.23	.42
33	.42	.49
34	.25	.43
35	.42	.49
36	.49	.50
Total	19.99	16.42

FIGURE 9



difficult items are obvious from an examination of the graph and will be discussed later in this section. The overall mean score and standard deviation for the TIPS test were 19.99 and 16.42 respectively. Item standard deviations ranged from .12 to .50 with a mean item standard deviation of .46.

The analysis of data on the five subscales of the TIPS test shows a small increase in scores with each higher grade level. This is true for each subscale. This increase is shown on Table 11 and Figure 10. A comparison of subscale mean scores cannot be made from the data as shown because of unequal item numbers. The subscale measuring abilities with identifying variables consisted of 12 items. Operationally defining, identifying testable hypotheses, experimental design, and graphic analysis of data subscales consist of 6, 9, 3, and 6 items respectively.

The relative progression of scores by grade level is shown in Figure 10.

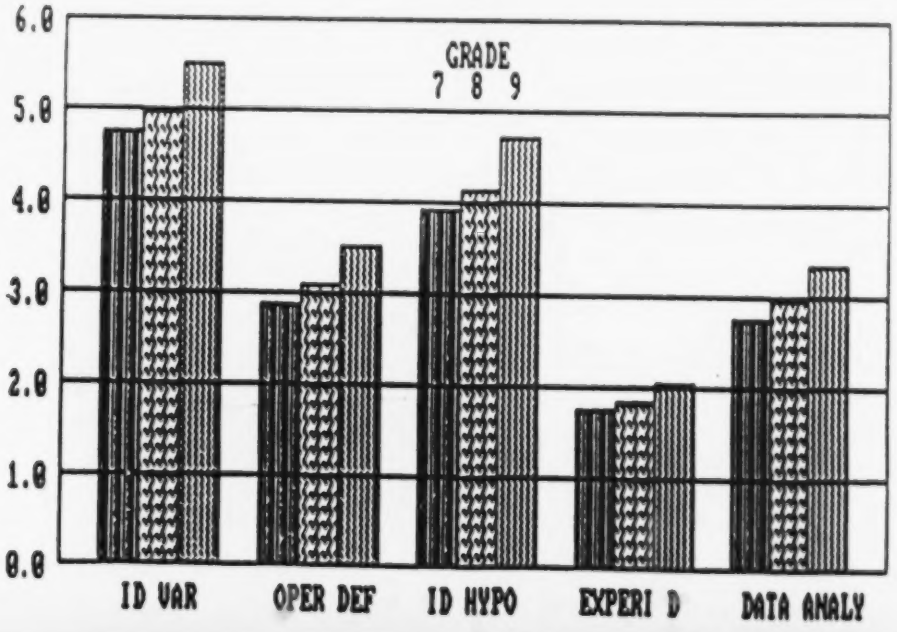
TABLE 11

Descriptive Statistics for the TIPS - SUB SCALES by GRADES

Sub Scales	Grade	Mean	S.D.
Identifying Variables	7	4.77	2.13
	8	4.96	2.13
	9	5.48	2.14
Operationally Defining	7	2.87	1.62
	8	3.09	1.57
	9	3.52	1.64
Identifying Testable Hypotheses	7	3.93	1.95
	8	4.12	2.13
	9	4.72	2.07
Experimental Design	7	1.77	.99
	8	1.85	.95
	9	2.05	.94
Graphic Analysis of Data	7	2.73	1.50
	8	2.97	1.52
	9	3.34	1.55

N
grade 7 = 943
grade 8 = 1358
grade 9 = 964

FIGURE 10 TIPS SUBSCALE SCORES BY GRADE



When scores are examined according to the variable of sex, very little difference is observed between male and female subjects. These results are shown in Table 12 and Figure 11. Females score slightly higher than males at the eighth and ninth grade levels. However, the scores are practically identical.

Grade level differences are small with an observed increase with age. There is an approximate one point gain in scores between the seventh and eighth grade. Likewise, a small gain of approximately two points is observed between the eighth and ninth grade levels.

From these results, it appears that males and females perform especially well with integrated process skills and show a small improvement with increasing age or grade level.

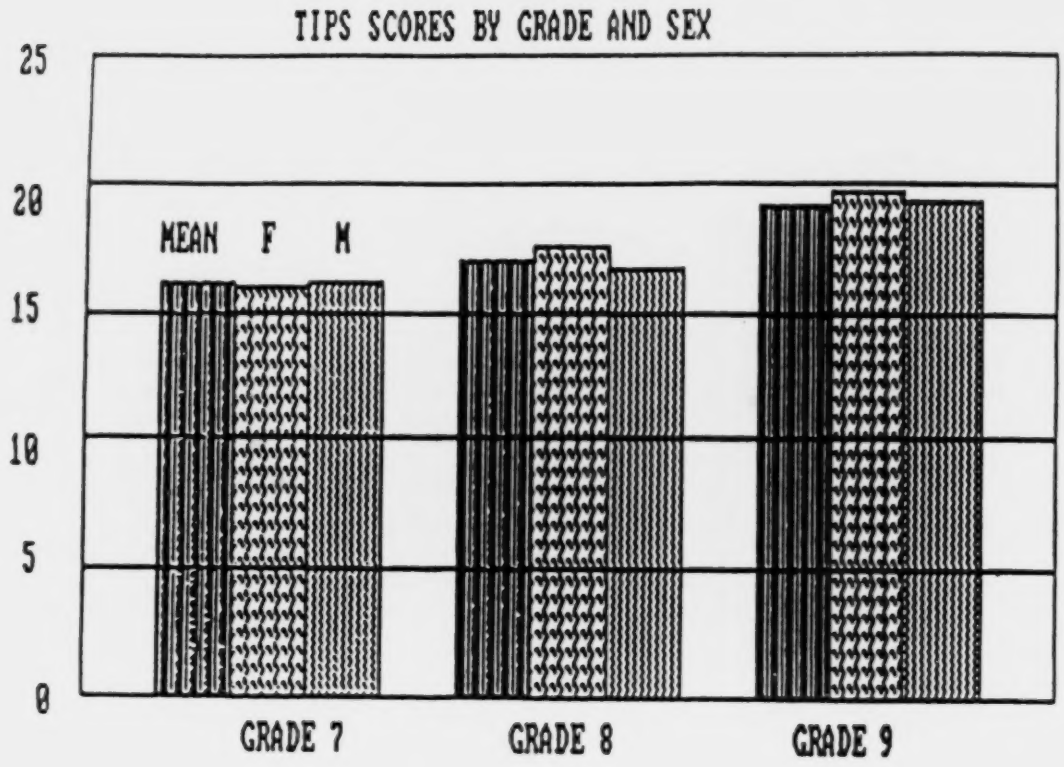
When the subscales are compared on an equivalent basis by computing the average subscale mean score, the relative difficulty of the subscales can be compared. The most difficult subscale task was identifying variables with a mean of .42.

TABLE 12

Descriptive Statistics for the TIPS by Grade/Sex

Grade	Sex	N	Mean	S.D.	Reliability
7		943	16.06	4.14	.81
	F	406	15.94	3.74	
	M	403	16.11	4.45	
8		1358	16.98	4.03	.81
	F	438	17.58	4.20	
	M	424	16.69	3.83	
9		940	19.12	4.18	.82
	F	439	19.56	4.09	
	M	381	19.30	4.34	
Overall		3139	17.34	4.22	.82

FIGURE 11



Other subscales follow in ascending order of average item mean score: Identifying Testable Hypothesis (.47); Graphic Analysis of Data (.50); Operationally Defining (.53); and Experimental Design (.63). From these data, it appears that students score lower on integrated process skills of identifying variables and hypothesis testing. Students score highest on skills of experimental design.

The relative item difficulty is illustrated in Figure 9. A number of items received less than 50 percent correct score as shown in Table 10 and Figure 9. The lowest scoring item was Number 27, with a mean score of .1. It is from the subscale on identifying testable hypotheses. Only two items out of 12 on identifying variables were less than 50 percent correct. They were numbers 1 and 3.

A comparison of relative difficulty between subscales and grade levels is shown on Table 13. The same difficulty of subscales scores is shown between grade levels.

TABLE 13

Descriptive Statistics for the TIPS - SUB SCALES

Grade	Sub Scales	N	Mean	S.D.
	Identifying Variables	943	4.77	2.13
	Operationally Defining	943	2.87	1.62
7	Identifying & Stating Hypotheses	943	3.93	1.95
	Designing Investigations	943	1.77	.99
	Graphing & Interpreting Data	943	2.73	1.50
	Identifying Variables	1358	4.96	2.13
	Operationally Defining	1358	3.09	1.59
8	Identifying & Stating Hypotheses	1358	4.12	2.13
	Designing Investigations	1358	1.85	.95
	Graphing & Interpreting Data	1358	2.97	1.52
	Identifying Variables	944	5.48	2.14
	Operationally Defining	944	3.52	1.44
9	Identifying & Stating Hypotheses	944	4.72	2.07
	Designing Investigations	944	2.05	.94
	Graphing & Interpreting Data	944	3.34	1.55
	Identifying Variables			
	Operationally Defining			
TOTAL	Identifying & Stating Hypotheses			
	Designing Investigations			
	Graphing & Interpreting Data			

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Science Attitude Scale

The Science Attitude Scale is a survey designed to measure students' opinions about science. Scores on this test can range from 20, a very negative attitude toward science, to 100, a very positive attitude. A score of 60 indicates a generally positive attitude toward science. Overall, seventh graders reflected the most positive attitude with a mean score of 71.3%, but

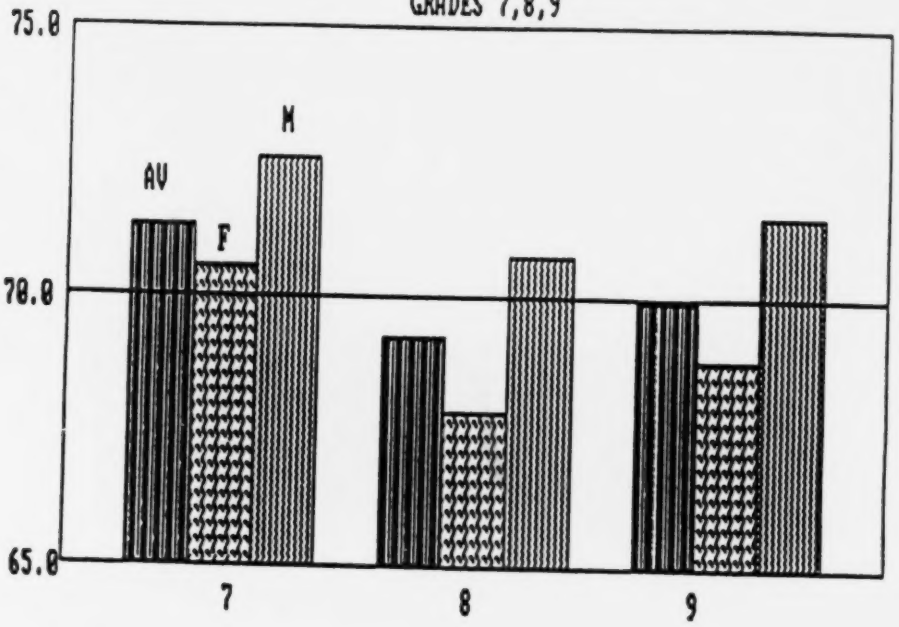
eighth and ninth graders also indicated having positive attitudes about science with mean scores of 69.21 and 69.92, respectively. This trend of declining positive attitudes toward science between the seventh and eighth grade has also been observed in other studies. At all grade levels, males scored higher than females by at least two points, reflecting a slightly more positive attitude from males. These data are summarized in Table 14 and Figure 12.

TABLE 14

Descriptive Statistics for the Science Attitude Scale (item response - %)

N	Item	Scale Response/percent					Mean	S.D
		1	2	3	4	5		
3272	1	3.7	6.6	13.8	50.7	25.1	3.87	.99
3247	2	3.9	5.6	8.6	40.9	41.1	4.1	1.02
3240	3	7.06	14.0	17.5	39.5	22.3	3.55	1.17
3233	4	6.8	14.8	19.8	39.6	19.0	3.49	1.15
3256	5	8.8	23.3	37.8	23.9	6.2	2.95	1.03
3253	6	4.9	10.1	10.4	46.2	28.3	3.38	1.09
3246	7	3.3	12.4	15.3	45.1	23.9	3.74	1.06
3241	8	6.4	11.7	10.9	39.4	31.6	3.78	1.19
3237	9	6.6	14.8	17.9	44.5	16.1	3.49	1.13
3250	10	5.3	9.7	11.6	42.8	30.6	3.84	1.12
3229	11	8.7	20.0	20.0	35.0	16.3	3.3	1.20
3223	12	4.9	12.0	11.6	47.8	23.6	3.73	1.10
3223	13	6.7	14.1	13.7	42.5	22.9	3.61	1.18
3221	14	8.2	15.2	17.7	38.7	20.1	3.47	1.20
3244	15	11.3	27.0	18.0	28.6	15.0	3.10	1.27
3244	16	6.0	11.4	11.3	40.1	31.1	3.79	1.17
3244	17	6.4	7.3	10.4	39.0	37.0	3.9	1.16
3244	18	20.2	35.1	26.2	11.0	7.5	2.5	1.15
3240	19	7.7	19.4	22.4	37.3	13.2	3.29	1.15
3255	20	8.0	16.0	20.5	39.8	15.7	3.39	1.14
total		7.3	15.5	16.95	37.95	22.55	69.99	16.44

FIGURE 12 SCIENCE ATTITUDE SCORES
BY SEX
GRADES 7,8,9



The statement most disagreed with (by 82%) was, "I do not like science, and it scares me to have to take it." The statement most agreed with (by 61.8%) was, "Science is very interesting to me, and I enjoy science courses." The item mean scores are shown in Figure 13. Only two items, 5 and 18, received a mean score below the neutral position.

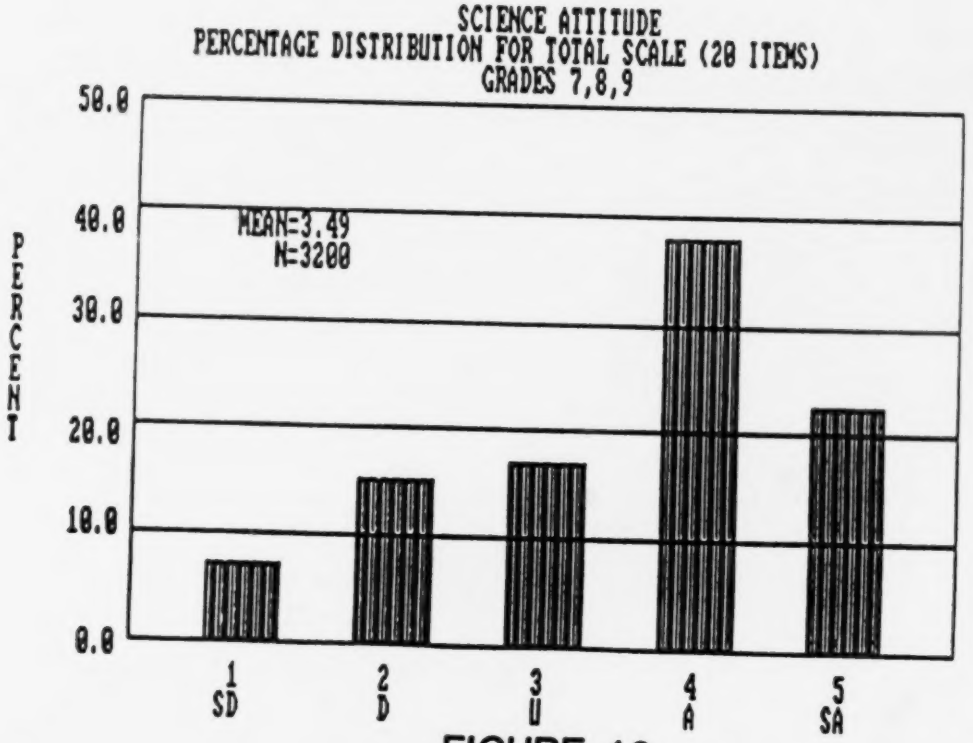


FIGURE 13

Student Questionnaire

The purpose of the Student Questionnaire was to learn more about the various science activities that students participate in, at school and out of school. Part A deals with frequency of activities in school, and Part B deals with activities out of school. Scores could range from 20 to 87 if the questionnaire was answered completely, but because not all students finished the questionnaire, scores ranged from 1-75 for Part A and 1-84 for Part B. Students' scores were always higher in Part B, out-of-school activities. This held true when broken down by grades and sex. The overall mean scores were 39.95 for in-school activities and 45.52 for out-of-school activities (see Table 15 and Figures 14 and 15). Seventh graders scored highest on both parts,

Table 15

Student Questionnaire Item means (In-School and Out-of-School)

	In-School		Out-of-School	
Item #	Mean	SD	Mean	SD
1.	1.65	.58	1.58	.62
2.	1.48	.55	1.36	.55
3.	2.12	.72	1.90	.74
4.	1.22	.45	1.41	.60
5.	1.48	.60	1.87	.63
6.	1.18	.42	1.34	.56
7.	1.10	.34	1.13	.41
8.	1.26	.55	2.26	.71
9.	1.14	.40	1.42	.64
10.	1.31	.53	1.29	.55
11.	1.62	.62	1.66	.68
12.	1.45	.59	1.54	.67
13.	1.20	.46	1.54	.69
14.	1.22	.50	1.84	.76
15.	1.82	.71	1.83	.73
16.	1.78	.69	1.30	.56
17.	1.25	.49	1.84	.76
18.	1.29	.56	1.14	.42
19.	1.23	.47	1.23	.49
20.	1.16	.46	1.54	.74
21.	1.64	.68	1.80	.72
22.	2.09	.68	1.61	.71
23.	1.59	.68	1.48	.66
24.	1.57	.72	1.57	.78
25.	1.44	.70	2.52	.70
26.	1.29	.59	1.93	.82
27.	1.22	.51	1.66	.73
28.	1.69	.75	2.24	.72
29.	1.30	.56	1.78	.77
Total	39.94	8.56	45.53	10.13

FIGURE 14

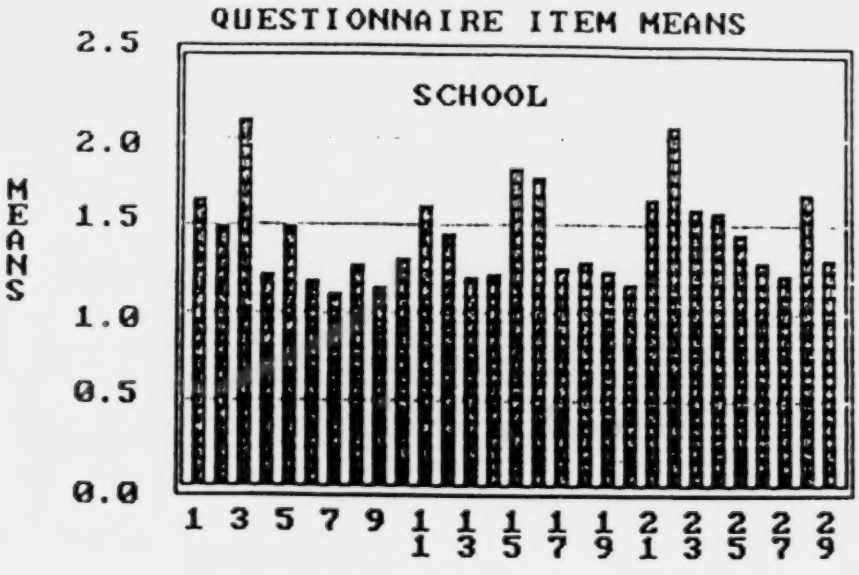
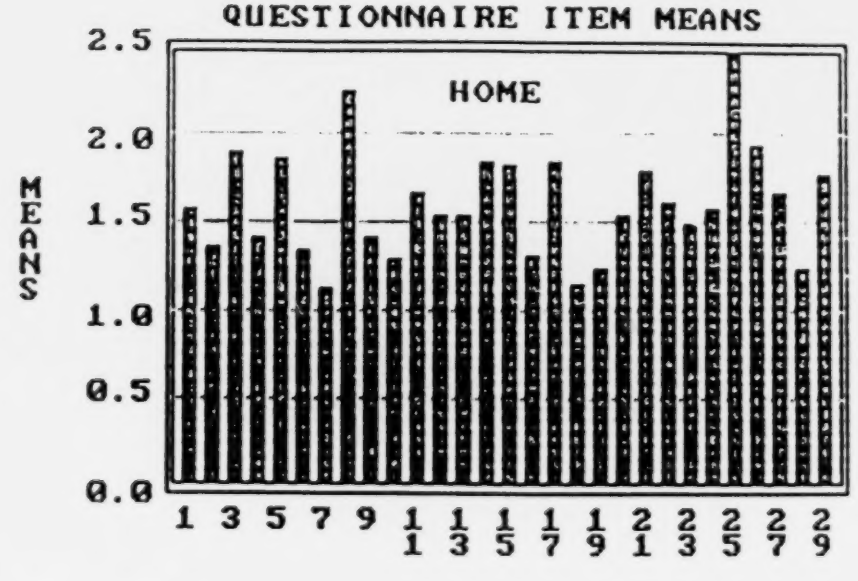
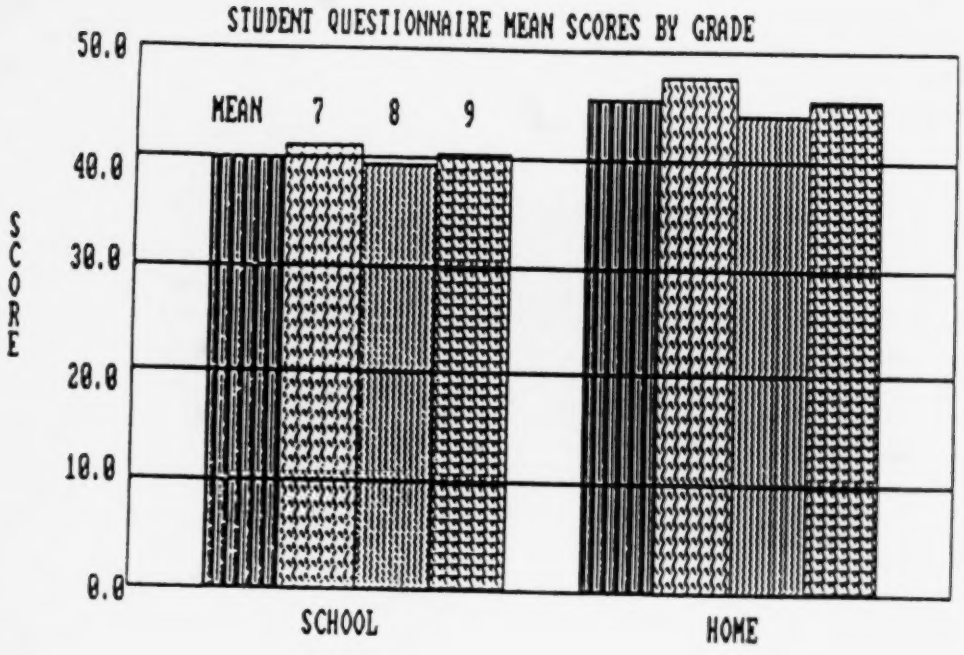


FIGURE 15



while ninth graders scored second, and eighth graders indicated having the lowest frequency of participation in science activities, both in and out of school. This is shown in Figure 16.

FIGURE 16



The two items which received the highest rating for in-school activities were numbers 3 and 22. Visiting the library to read science books and periodicals and using a microscope are frequent experiences in school. Bird watching and receiving private tutoring in science are the least frequent school experiences indicated from this questionnaire.

The most frequent out-of-school experiences were caring for birds, rabbits, cats, dogs, or hamsters and taking part in camping, fishing, or hiking activities. The least frequent out-of-school experiences were receiving private tutoring in science and taking part in science club activities.

Teacher Questionnaire

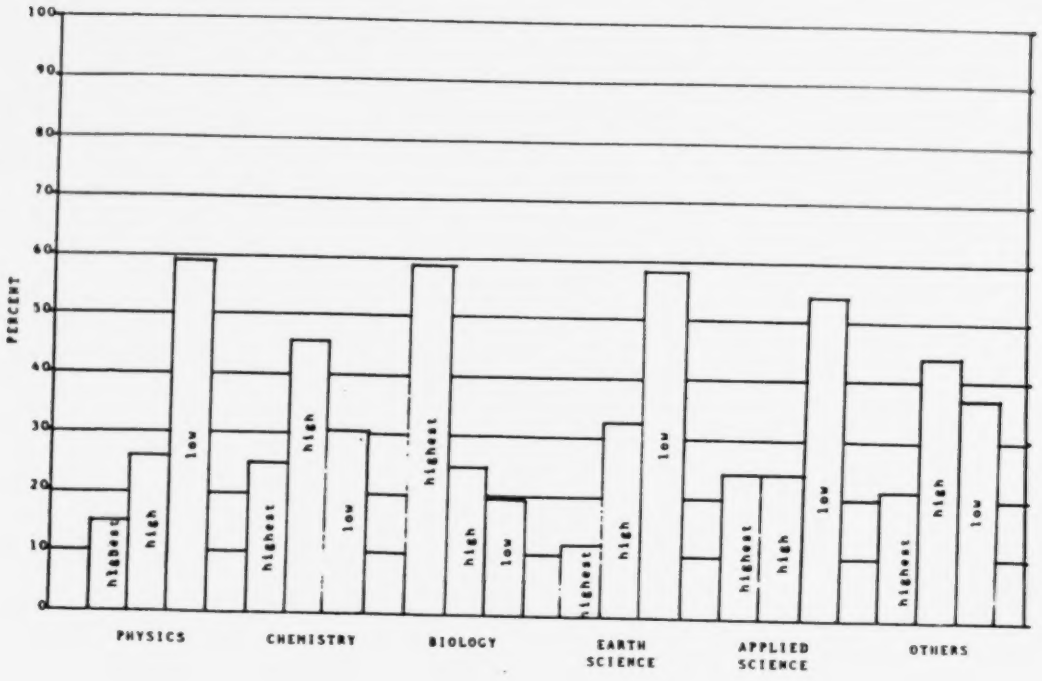
The teacher questionnaire was completed by 33 science teachers. The teachers were from the following ten school systems throughout North Carolina: Greenville City, Alamance, Buncombe, Cumberland, Forsyth, Guilford, Mecklenberg, Pitt, Wake, and Wilson Counties. As stated in the questionnaire, the aim was to find out ways of improving science education. A copy of the questionnaire and a complete report are found in the Appendix. Following is a summary of the data from this survey.

The first five questions consisted of background information on teachers and their experience. Among the 33 teachers, there were 9 males and 24 females. Ages ranged from 23 to 60 years old, with a mean of 38.7 years. The mode and median ages were both 37 years. Question 3 asked how much teaching experience the individual has. Years of experience ranged from 2 to 26 years, with a mean of 14.13 years. The median years experience was 13.5 years, and the mode was 20 years (five teachers had 20 years of teaching experience).

Question 4 asked the teachers to list the science subjects and number of classes they were presently teaching. The number of science classes taught were distributed as follows: one teacher taught one science class, one taught two classes, two taught three classes, two taught four classes, nineteen taught five classes, and eight teachers taught six science classes. The subjects taught were physical science by 13 teachers, chemistry by 1, earth science by 12, life science by 11, physics by 2, sixth grade science by 2, and exploratory science by 1 teacher. Courses listed other than science subjects were math by five teachers, health by one, and social studies by one teacher.

Question 5 concerns the teachers' educations. Sixteen teachers had undergraduate degrees, while 17 teachers had graduate degrees. None of them listed any other type of degree. In the next part of the question, they were asked to rank subjects in terms of the amount of content taken at college/university. There were three rankings: 1=highest, 2=high, and 3=low. The subjects ranked were physics, chemistry, biology, earth science, applied science, and others. Biology received a rank of highest by the largest percentage of teachers. Chemistry was rated as high amount of content taken by the largest percentage, and physics was given a rating of low by the most teachers (59%). The results of each subject's rankings are shown in Figure 17.

FIGURE 17
RANK OF SCIENCE SUBJECTS BY AMOUNT OF CONTENT TAKEN IN COLLEGE/UNIVERSITY



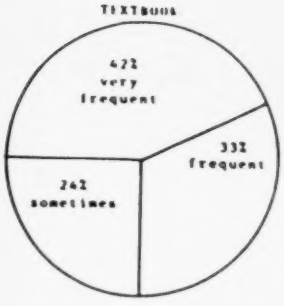
The last part of Question 5 asks about certification. Twenty-seven teachers listed General Science as an area of certification (middle grades or secondary). Other specific areas named were biology, chemistry, physics, physical science, earth science, and geology. Areas not in the field of science that were listed were math, home economics, special education, administration, gifted and talented, social studies, health, language arts, and guidance.

Question 6 asked teachers to indicate how often they used specific items in teaching science. Each item was ranked as follows: 1=very frequent, 2=frequent, 3=sometimes, 4=rare, and 5=never or not applicable. Each item rated is summarized in the pie graphs in Figures 18-20.

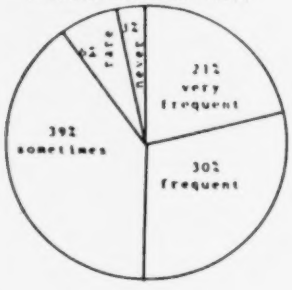
FIGURE 18

THE FREQUENCY OF TEACHING AIDS USED IN TEACHING SCIENCE

TEXTBOOK



EXPERIMENTAL WORKSHEET

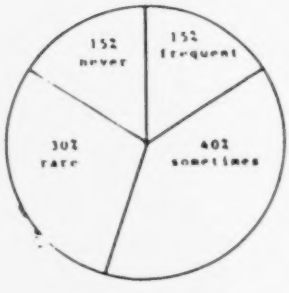


PUPIL ACTIVITY WORKBOOK

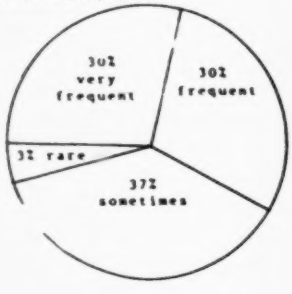
FIGURE 19

THE FREQUENCY OF TEACHING AIDS USED IN TEACHING SCIENCE

TV PROGRAMS



OTHER AV AIDS (films, overhead projectors, etc.)



SCIENCE READING MATERIALS

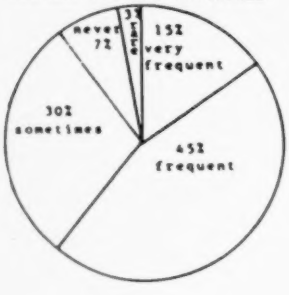
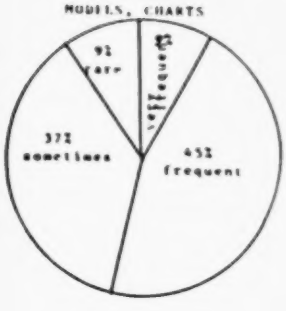


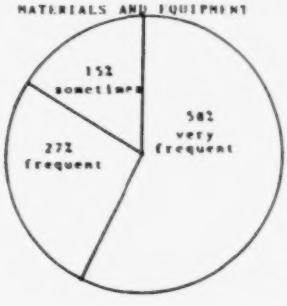
FIGURE 20

THE FREQUENCY OF TEACHING AIDS USED IN TEACHING SCIENCE

MODELS, CHARTS



MATERIALS AND EQUIPMENT



MICROCOMPUTERS

In the area of teaching aids, they ranked textbooks, experimental worksheets, pupil activity workbooks, TV programs, other TV aids (films, overhead projectors, etc.), science reading materials, models and charts, materials and equipment, and microcomputers. Materials and equipment had the largest percentage of very frequent responses, with 58%. The item with the largest percentage of never responses was microcomputers, with 42%.

In teaching and learning activities, lecture/discussion, teacher demonstration, small group discussion, self-paced activities, group activities, and laboratories were the items rated. Laboratory activities had the most very frequent responses with 39%, while self-paced activities received the only never responses with 9%. These data are shown in Figures 21 and 22.

FIGURE 21

THE FREQUENCY OF USE OF TEACHING AND LEARNING ACTIVITIES IN TEACHING SCIENCE

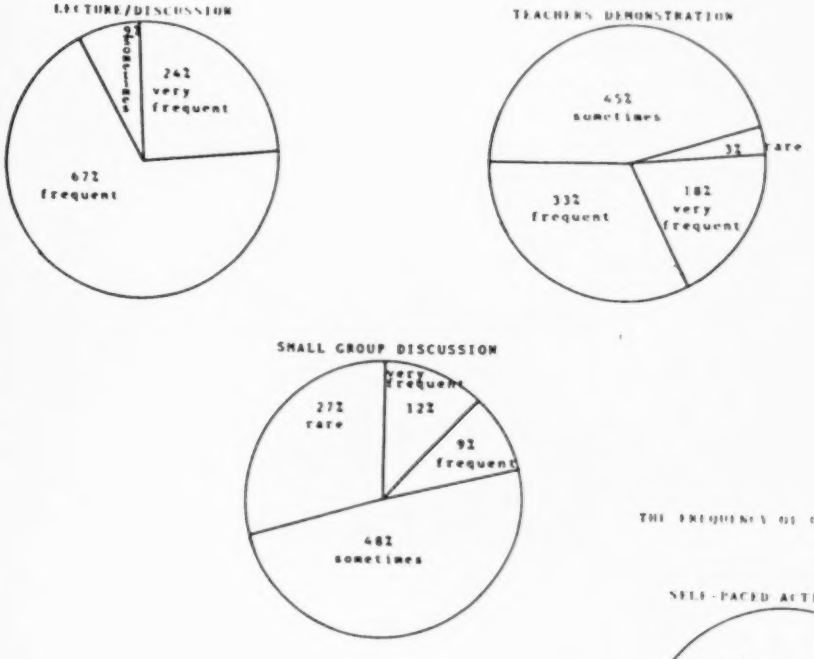
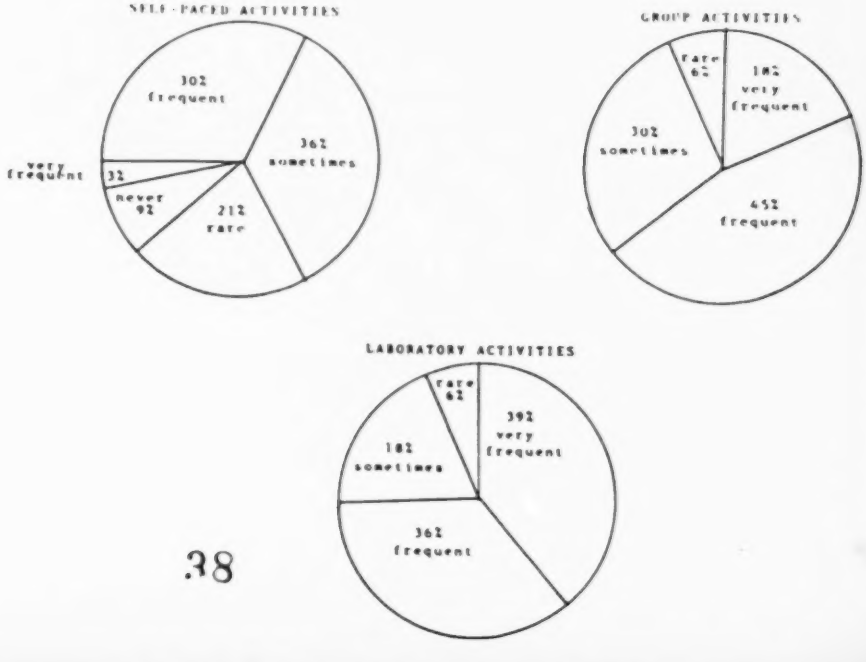


FIGURE 22

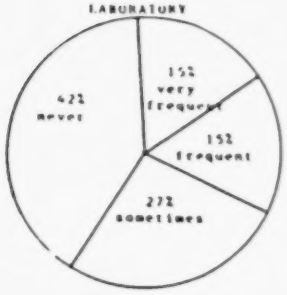
THE FREQUENCY OF USE OF TEACHING AND LEARNING ACTIVITIES IN TEACHING SCIENCE

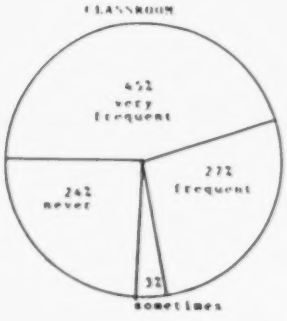


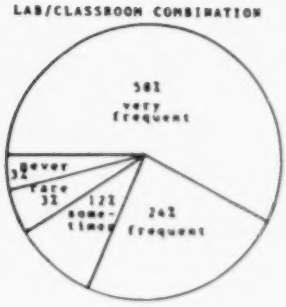
Items in the use of teaching and learning facilities were laboratory; classroom; lab/classroom combination; school grounds; outdoor study areas; science trips away from school; field trips to science centers, museums, etc.; and field trips to parks and natural areas. Lab/classroom combination was rated very frequent most with 58%, and the laboratory alone received a never rating the most with 42%. This is shown graphically in Figures 23 and 24.

FIGURE 23

THE FREQUENCY OF USE OF TEACHING AND LEARNING FACILITY IN TEACHING SCIENCE







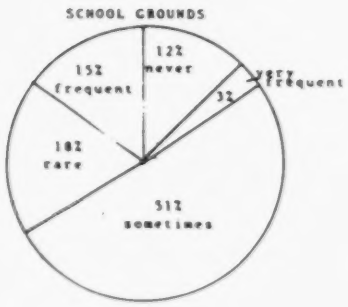
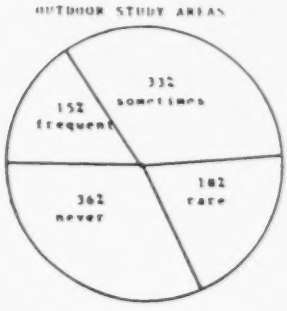
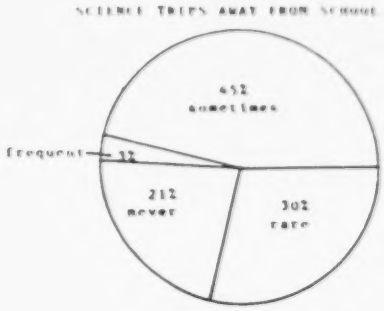
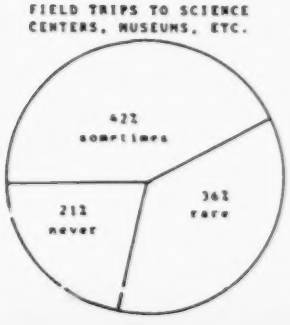


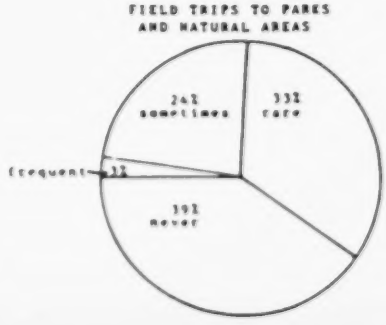
FIGURE 24

THE FREQUENCY OF USE OF TEACHING AND LEARNING FACILITY IN TEACHING SCIENCE









Paper and pencil test, short answer test, essay test, interview, observation, reports, student projects, improvised teaching aids, teacher-designed evaluations, evaluations to help students gain further understanding of science, and evaluations used to modify teaching plans were the items rated in the area of evaluation. Teacher-designed evaluations had the largest percentage of very frequent responses with 55%. Interviews were expressed as never being used by the most with 36%. These data are shown in Figures 25-27.

FIGURE 25

THE FREQUENCY OF USE OF EVALUATION IN TEACHING SCIENCE

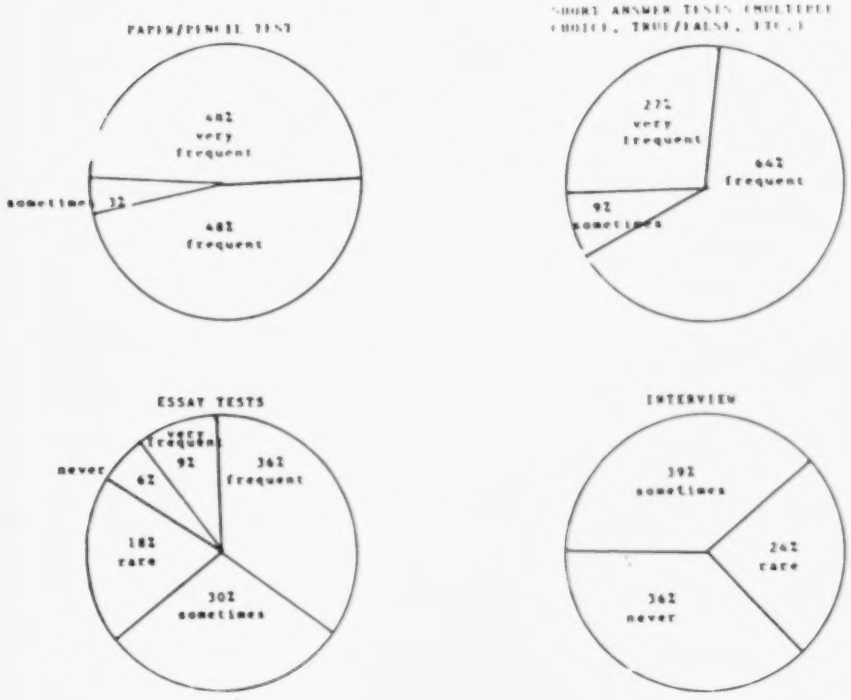


FIGURE 26

THE FREQUENCY OF USE OF EVALUATION IN TEACHING SCIENCE

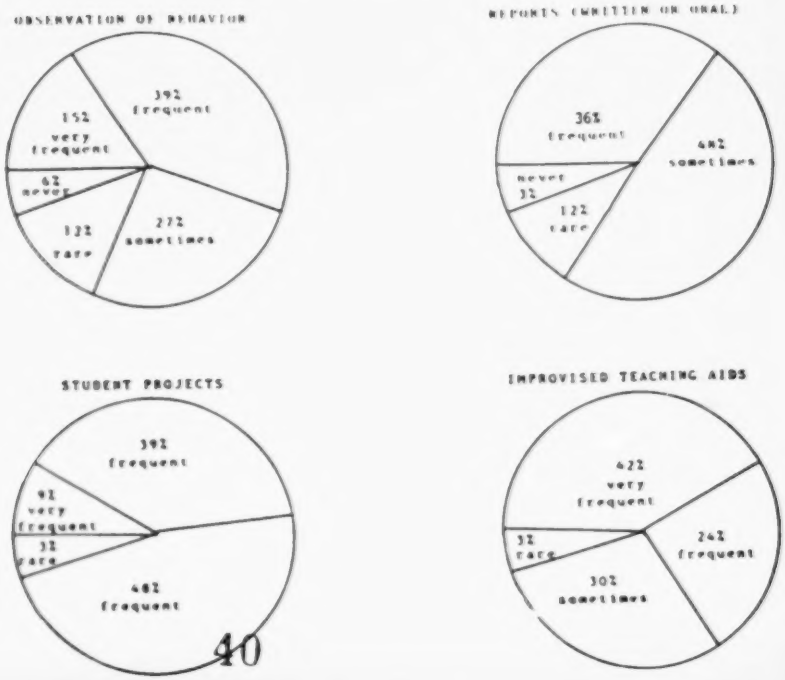
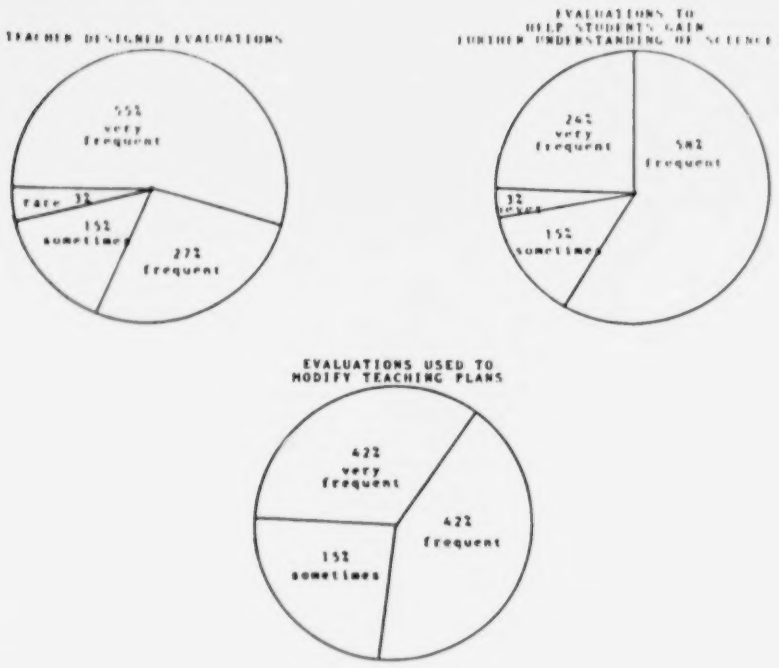


FIGURE 27

THE FREQUENCY OF USE OF EVALUATIONS IN TEACHING SCIENCE



In the next question, teachers were asked about in-service programs/workshops they had attended. All but one of the 33 teachers indicated they had participated in a science in-service program within the last three years. As to sponsors of these programs, 12 listed university, 14 listed local educational agency, and 16 said they were state-sponsored programs. Some of the programs mentioned most frequently were computers, lab safety, and physics. Other programs or workshops that were named were general education, science content, wildlife, reasoning/problem solving, Carolina Power and Light Program, field trips, geology, writing in science instruction, teaching science to the slow learner, teaching aids in science, teaching the non-achiever, Math and Science School, laboratory activities, ecology, astronomy, physical science, nature in the classroom, and industries in science education.

Twenty-three teachers said they had participated in state or national science teachers' conferences within the last three years. Five had attended one meeting, eight had been to two meetings, five to three meetings, one to four meetings, two to five meetings, one to six meetings, and one to ten meetings. Concerning science associations, 18 are members of the North Carolina Science Teachers Association (NCSTA), and 8 are members of the National Science Teachers Association (NSTA). Other associations mentioned were County Science Teachers Association, North Carolina Association of Educators, National Education Association, American Chemical Society, American Association of Physics Teachers, National Earth Science Teachers Association,

Southern Appalachian Mineral Society, National Marine Education Association, Mid-Atlantic Marine Education Association, North Carolina Outdoor Educators Association, and North Carolina Classroom Teachers of Mathematics.

The final two questions concern science literature and science education literature. Twenty-one teachers said they very frequently read science-related literature (e.g., magazines, periodicals, and specialized science books), and 11 said sometimes, while 1 said rarely. Science literature most often read was Discover, Science '84, National Geographic, Science World, Scientific America, and Wildlife. Other literature mentioned was Astronomy, Omni, Science News, Current Science, Science Digest, Coastal Watch, Outdoor Life, Popular Science, Newsweek, Nature, Health, World, Current, Softalk, and Family Computing.

Twelve teachers very frequently read science education related literature, while 19 said they sometimes did, and 2 said they rarely did. Science and Children and The Science Teacher were mentioned most. Other educational literature read was Children's Science, Journal of Chemistry Education, Science Scope, Today's Education, Physics Teacher, The Biology Teacher, Physics Today, Journal of Science and Math, and The Earth Scientist.

There were no significant differences in the teaching methods, attendance at conferences, membership in professional organizations, and literature read between the teachers who had Masters degrees and those who did not have graduate degrees.

In the initial stages of this project, the team tried to explore ways of analyzing the data from the Teacher Questionnaire to study the relationships between teachers and students. The nature of the data and the small number of teachers did not make this analysis appropriate.

Research Questions

In addition to the information derived from the descriptive data of this study, a number of research questions were asked. The relationships between various variables were selected and tested.

The research questions investigated were:

1. Is there a relationship between student attitudes and measures of logical thinking?

2. Is there a relationship between student attitudes and measures of science process skills?

3. Is there a relationship between student measures of logical thinking and their science process skills?

4. Is there a relationship between student activities and measures of student attitudes toward science?

5. Is there a relationship between student activities and integrated science process skills?

6. Is there a relationship between student activities and logical thinking skills?

Analysis of these questions using the SAS PROC CORR procedures provided correlational coefficients. The results of the analysis are shown on Table 16.

Correlational coefficients are shown for the total sample and by grade levels. Most all relationships proved to be statistically significant. However, with such a large sample size, this is expected. In consideration of this factor, judgment must be made as to the practical significance of the relationships. The investigators of this study do not consider questions 1, 2, 4, 5, and 6 to be meaningful. We do find a moderately strong relationship to exist between the integrated science process skills and logical thinking as measured by instruments in this study ($r=.64$, $p<.0001$). This relationship has been observed in other studies. Whether learned abilities with integrated process skills enhance logical thinking or vice versa is not known. Table 16 gives a summary of the correlation coefficients related to the research questions.

Table 16

Correlational Coefficients for Research Questions

Instruments	Total	Grades 7	8	9
ATTITUDE:Galt	.14 ***	.21 ***	.11 ***	.14 ***
ATTITUDE:TIPS	.15 ***	.25 ***	.08 **	.16 ***
ATTITUDE:SCHOOL	.13 ***	.08 **	.15 ***	.13 ***
ATTITUDE:HOME	.22 ***	.21 ***	.21 ***	.23 ***
GALT:TIPS	.63 ***	.59 ***	.61 ***	.65 ***
GALT:SCHOOL	.01	-.004	-.02	.01 **
GALT:HOME	.15 ***	.16 ***	.15 ***	.21 ***
TIPS:SCHOOL	.04*	-.03	.06 **	.11 *
TIPS:HOME	.18 ***	.14 ***	.21 ***	.22 ***

***p < .0001

**p < .008

*p < .03

Summary, Conclusions, and Recommendations

Summary

The analysis of the data points out the following as being significant for the more than 3,000 students tested in North Carolina.

1. A relatively high percentage of students in grades 7, 8, and 9 scored at the concrete level on the GALT test (69.3%). This data is consistent with the results obtained from other research studies in the U.S. The number of students who scored in the "formal" stage was 9.3%. The data obtained by the Japanese research team from the same test administered to more than 4,000 junior high school students in Japan showed that 32% were classified as "concrete," and 32% were also classified as "formal" thinkers. The scores of the North Carolina students increased by grade level, as one might expect. The same was true for the Japanese students tested. However, in grade 9, the North Carolina students tested showed only 13% classified as "formal" thinkers, while 42% of the ninth grade students tested in Japan were classified in this category. The results of this test (GALT) showed very dramatic differences between the students tested in North Carolina and the students tested in Japan. The students in both groups made significant gains on the test from grade 7 to 9. The large difference in the scores in the seventh grade carried through to grade 9. The implication is that the low scores in grade 7 for the North Carolina students is the cumulative result of the education of these students in the elementary school (grades K-6). The tests were given in early November, and it seems reasonable to assume that the test measured the skills acquired during their previous education experience. Recent studies in North Carolina have shown that very little time and effort have been devoted to elementary school science, and the test data may reflect this condition.

2. The scores from the TIPS II test showed an increase in the scores from the seventh to ninth grades for the students tested in North Carolina and Japan, with the greatest increase shown between the eighth and ninth grades for both groups. The Japanese students tested with TIPS II had significantly higher scores at each of the three grade levels than the students tested in North Carolina. The greatest differences between the North Carolina and Japanese students tested were in the subscales of identifying variables and the graphic analysis of the data. The inability of the North Carolina students to handle the integrated process skills may reflect the lack of experience these students have had in their educational experiences in grades K-6.

3. There was a high correlation between the scores on the GALT and TIPS II tests for North Carolina students (.73) and Japanese students (.66). This was consistent with previous research using the two tests. How the two types of skills are related is not presently understood.

4. The data from the science attitude scale showed that the North

Carolina students had a positive attitude toward science at all three grade levels. There was a definite decrease in their scores from the seventh to the eighth grade, which would reflect the difference from the elementary school to the junior high school. Teachers in the junior high schools often complain about their students' decline in interest in studying science during the period from grade 7 to grade 9. The scores on the attitude toward science scale for the U.S. students were slightly higher than the scores on the same scales for the Japanese students.

5. The Student Questionnaire data showed that North Carolina students in grades 7, 8, and 9 seemed to participate in more science-related activities outside of school compared to the participation in these activities in school. The out-of-school activities could have been a part of an organized program of instruction such as Boy and Girl Scouts, 4-H Clubs, etc., as well as incidental or planned experiences with the family. No specific conclusions could be drawn from the data other than the reinforcement of the lack of in-school, hands-on, laboratory-type activities.

6. The data from the Teacher Questionnaire represented such a small number of teachers with a wide range of academic backgrounds and teaching experience that the only purpose that might be served would be to discount the fact that the teachers represented any homogeneous characteristics at all.

Conclusions

One conclusion that appears in this study is that in items of the skills measured by the GALT and TIPS II tests, the junior high school students tested in North Carolina showed that there is a great deal of room for improvement in these skills. The fact that on the GALT test 79% of the seventh grade students, 69% of the eighth grade students, and 61% of the ninth grade students tested were classified to be at the "concrete" level of thinking skills, according to the test authors, further illustrates this point. It seems to follow that more emphasis needs to be placed on the development of these skills in the elementary schools and the junior high school. The level of instruction provided for students must include many concrete experiences that could provide the basis for developing the higher order thinking skills that are desired. All too often the science curricula are centered around the vicarious experiences of listening to the teacher and reading the textbooks. Students need to have experience in the various specific skills in order for them to do well on tests like the GALT and TIPS II.

As a result of many direct observations in Japanese elementary and junior high schools during the past six years and the study of the textbooks used in these classrooms, it has seemed obvious to the North Carolina research team that more time was spent teaching science in the elementary schools and the number of hands-on, laboratory-type teaching activites was greater at all levels in the Japanese schools. There is no documentation for these differences being the reasons for Japanese junior high school students doing that much better than North Carolina students on the GALT and TIPS II tests.

Recommendations

1. More testing and research needs to be done on learning more about the relationship between logical thinking skills and integrated process skills.

2. Additional research is needed on how the science classroom activities are related to the development of these skills.

3. New curriculum programs need to be developed that will enhance the development of logical thinking and process skills.

4. Institutions who prepare teachers need to modify their curricula to include theoretical and practical experiences using techniques that promote the development of students' thinking skills.

5. Develop and implement cooperative research projects between countries like Japan and the U.S. in an effort to carry out recommendations 1-4.

APPENDIX

G A L T

GROUP TEST OF LOGICAL THINKING

(Revised 1983)

Developed by:

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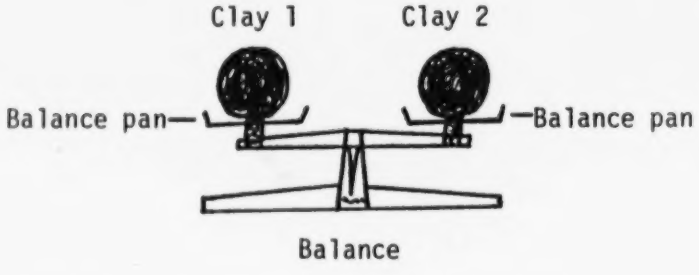
* Contact for information

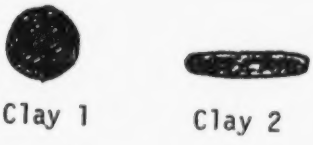
Item 1

Piece of Clay

Tom has two balls of clay. They are the same size and shape. When he places them on the balance, they weigh the same.



The balls of clay are removed from the balance pans. Clay 2 is flattened like a pancake.



WHICH OF THESE STATEMENTS IS TRUE?

a. The pancake-shaped clay weighs more.

b. The two pieces weigh the same.

c. The ball weighs more.

REASON

1. You did not add or take away any clay.

2. When clay 2 was flattened like a pancake, it had a greater area.

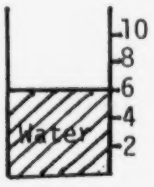
3. When something is flattened, it loses weight.

4. Because of its density, the round ball had more clay in it.

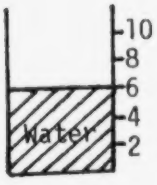
Item 2

Metal Weights

Linn has two jars. They are the same size and shape. Each is filled with the same amount of water.



Jar 1



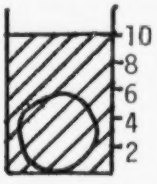
Jar 2

She also has two metal weights of the same volume. One weight is light. The other is heavy.

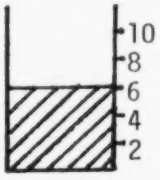
Light Metal Weight

Heavy Metal Weight

She lowers the light weight into jar 1. The water level in the jar rises and looks like this:



Jar 1



Jar 2

Heavy Metal Weight

IF THE HEAVY WEIGHT IS LOWERED INTO JAR 2, WHAT WILL HAPPEN?

a. The water will rise to a higher level than in jar 1.

b. The water will rise to a lower level than in jar 1.

c. The water will rise to the same level as in jar 1.

REASON

1. The weights are the same size so they will take up equal amounts of space.

2. The heavier the metal weight, the higher the water will rise.

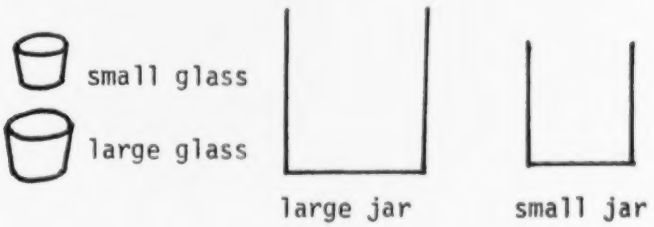
3. The heavy metal weight has more pressure, therefore the water will rise lower.

4. The heavier the metal weight, the lower the water will rise.

Item 3

Glass Size #2

The drawing shows two glasses, a small one and a large one. It also shows two jars, a small one and a large one.



It takes 15 small glasses of water or 9 large glasses of water to fill the large jar. It takes 10 small glasses of water to fill the small jar. HOW MANY LARGE GLASSES OF WATER DOES IT TAKE TO FILL THE SAME SMALL JAR?

a. 4

b. 5

c. 6

d. other

REASON

1. It takes five less small glasses of water to fill the small jar. So it will take five less large glasses of water to fill the same jar.

2. The ratio of small to large glasses will always be 5 to 3.

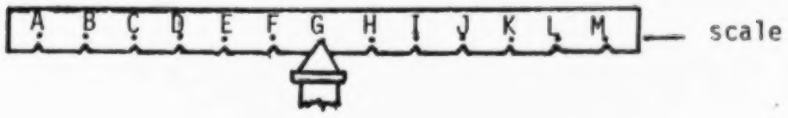
3. The small glass of half size of the large glass. So it will take about half the number of small glasses of water to fill up the same small jar.

4. There is no way of predicting.

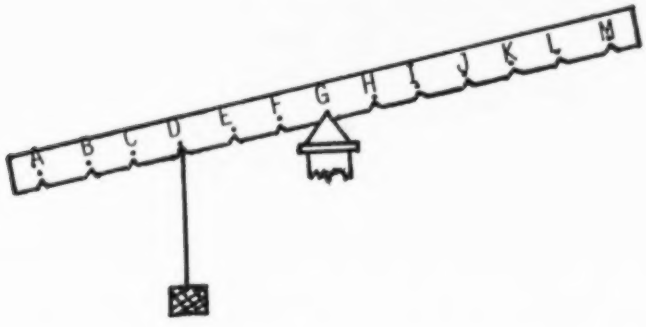
Item 4

Scale #1

Joe has a scale like the one below.



When he hangs a 10-unit weight at point D, the scale looks like this:



10-unit weight

WHERE WOULD HE HANG A 5-UNIT WEIGHT TO MAKE THE SCALE BALANCE AGAIN?

a. at point J

b. between K and L

c. at point L

d. between L and M

e. at point M

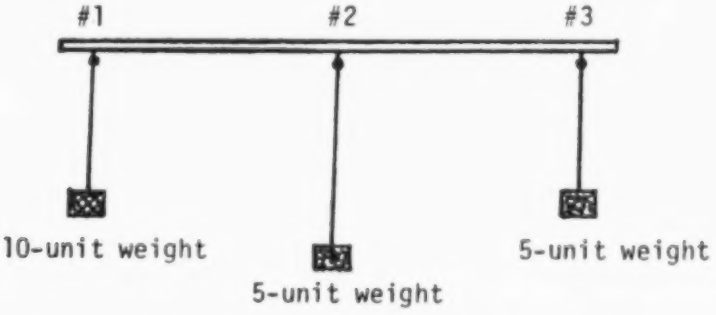
REASON

1. It is half the weight so it should be put at twice the distance.
2. The same distance as 10-unit weight, but in the opposite direction.
3. Hang the 5-unit weight further out, to make up its being smaller.
4. All the way at the end gives more power to make the scale balance.
5. The lighter the weight, the further out it should be hung.

Item 5

Pendulum Length

Three strings are hung from a bar. String #1 and #3 are of equal length. String #2 is longer. Charlie attaches a 5-unit weight at the end of string #2 and at the end of #3. A 10-unit weight is attached at the end of string #1. Each string with a weight can be swung.



Charlie wants to find out if the length of the string has an effect on the amount of time it takes the string to swing back and forth.

WHICH STRING AND WEIGHT WOULD HE USE FOR HIS EXPERIMENT?

a. string #1 and #2

b. string #1 and #3

c. string #2 and #3

d. string #1, #2, and #3

e. string #2 only

REASON

1. The length of the strings should be the same. The weights should be different.

2. Different lengths with different weights should be tested.

3. All strings and their weights should be tested against all others.

4. Only the longest string should be tested. The experiment is concerned with length not weight.

5. Everything needs to be the same except the length so you can tell if length makes a difference.

Item 6 Ball #1

Eddie has a curved ramp. At the bottom of the ramp there is one ball called the target ball.

There are two other balls, a heavy and a light one. He can roll one ball down the ramp and hit the target ball. This causes the target ball to move up the other side of the ramp. He can roll the balls from two different points, a low point and a high point.

a heavy ball

a light ball

Eddie released the light ball from the low point. It rolled down the ramp. It hit and pushed the target ball up the other side of the ramp.

He wants to find out if the point a ball is released from makes a difference in how far the target goes. TO TEST THIS, WHICH BALL WOULD HE NOW RELEASE FROM THE HIGH POINT?

a. the heavy ball

b. the light ball

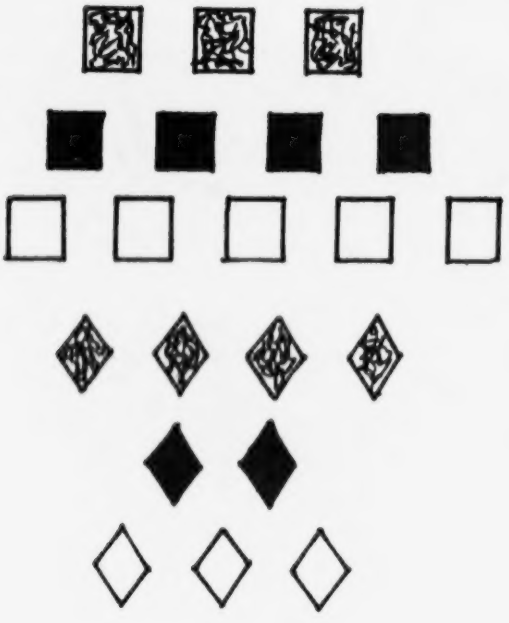
REASON

1. He started with the light ball he should finish with it
2. He used the light ball the first time. The next time he should use the heavy ball.
3. The heavy ball would have more force to hit the target ball farther.
4. The light ball would have to be released from the highpoint in order to make a fair comparison.
5. The same ball must be used as the weight of the ball does not count.

Item 7

Squares and Diamonds #1

In a cloth sack, there are



3 spotted wooden squares

4 black wooden squares

5 white wooden squares

4 spotten wooden diamonds

2 black wooden diamonds

3 white wooden diamonds

All of the square pieces are the same size and shape. The diamond pieces are also the same size and shape. One piece is pulled out of the sack. WHAT ARE THE CHANGES THAT IT IS A SPOTTED PIECE?

a. 1 out of 3

b. 1 out of 4

c. 1 out of 7

d. 1 out of 21

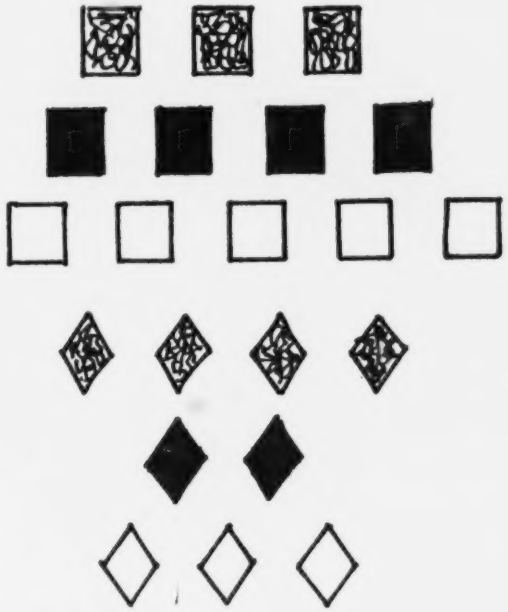
e. other

REASON

1. There are twenty-one pieces in the cloth sack. One spotted piece must be chosen from these.
2. One spotted piece needs to be selected from a total of seven spotted pieces.
3. Seven of the twenty-one pieces are spotted pieces.
4. There are three sets in the cloth sack. One of them is spotted.
5. One-fourth of the square pieces and 4/9 of the diamond pieces are spotted.

Item 8 Squares and Diamonds #2

In a cloth sack, there are



3 spotted wooden squares

4 black wooden squares

5 white wooden squares

4 spotten wooden diamonds

2 black wooden diamonds

3 white wooden diamonds

All of the square pieces are the same size and shape. The diamond pieces are also the same size and shape. Reach in and take the first piece you touch. WHAT ARE THE CHANCES OF PULLING OUT A SPOTTED DIAMOND OR A WHITE DIAMOND?

a. 1 out of 3

b. 1 out of 9

c. 1 out of 21

d. 9 out of 21

e. other

REASON

1. Seven of the twenty-one pieces are spotted or white diamonds.
2. 4/7 of the spotted and 3/8 of the white are diamonds.
3. Nine of the twenty-one pieces are diamonds.
4. One diamond piece needs to be selected from a total of twenty-one piece in the cloth sack.
5. There are 9 diamond pieces in the cloth sack. One piece must be chosen from these.

Item 9

The Mice

A farmer observed the mice that live in his field. He found that the mice were either fat or thin. Also, the mice had either black tails or white tails.

This made him wonder if there might be a relation between the size of a mouse and the color of its tail. So he decided to capture all of the mice in one part of his field and observe them. The mice that he captured are shown below.

DO YOU THINK THERE IS A RELATION BETWEEN THE SIZE OF THE MICE AND THE COLOR OF THEIR TAILS (THAT IS, IS ONE SIZE OF MOUSE MORE LIKELY TO HAVE A CERTAIN COLOR TAIL AND VICE VERSA)?

a. Yes

b. No

REASON

1. 8/11 of the fat mice have black tails and 3/4 of the thin mice have white tails.
2. Fat and thin mice can have either a black or a white tail.
3. Not all fat mice have black tails. Not all thin mice have white tails.
4. 18 mice have black tails and 12 have white tails.
5. 22 mice are fat and 8 mice are thin.

Item 10

The Fish

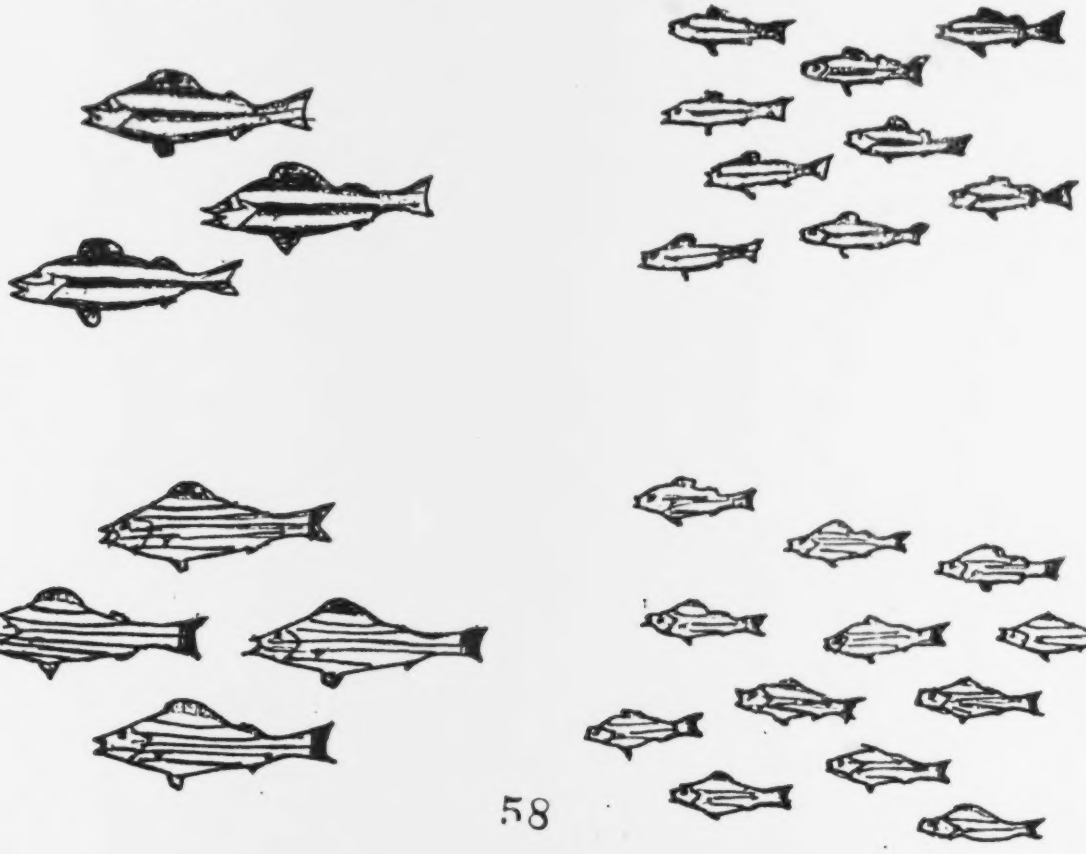
Some of the fish below are big and some are small. Also some of the fish have wide stripes on their sides. Others have narrow stripes. IS THERE A RELATIONSHIP BETWEEN THE SIZE OF THE FISH AND THE KIND OF STRIPES IT HAS (THAT IS, IS ONE SIZE OF FISH MORE LIKELY TO HAVE A CERTAIN TYPE OF STRIPES AND VICE VERSA)?

a. Yes

b. No

REASON

1. Big and small fish can have either wide or narrow stripes.
2. 3/7 of the big fish and 9/21 of the small fish have wide stripes.
3. 7 fish are big and 21 are small.
4. Not all big fish have wide stripes and not all small fish have narrow stripes.
5. 12/28 of fish have wide stripes and 16/28 of fish have narrow stripes.



Item 11

The Dance

After supper, some students decide to go dancing. There are three boys: ALBERT (A), BOB (B), and CHARLES (C), and three girls: LOUISE (L), MARY (M), and NANCY (N).

Albert (A) Bob (B) Charles (C) Louise (L) Mary (M) Nancy (N)

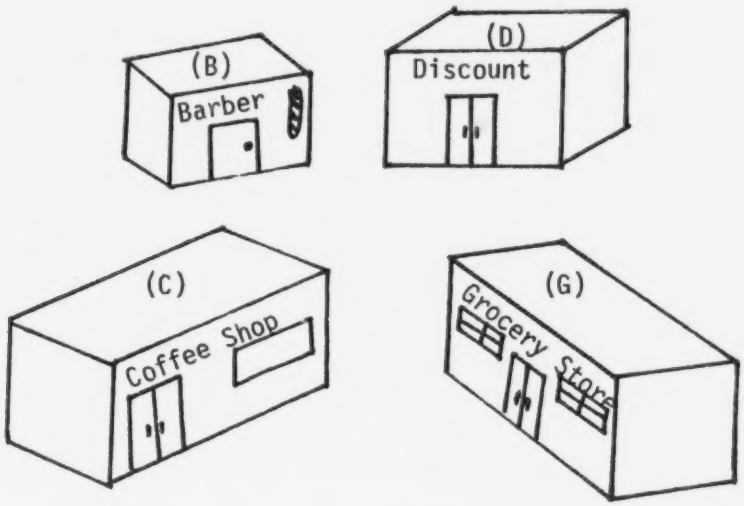
One possible pair of dance partners is A-L, which means ALBERT AND LOUISE.

LIST ALL OTHER POSSIBLE COUPLES OF DANCERS. BOYS DO NOT DANCE WITH BOYS, AND GIRLS DO NOT DANCE WITH GIRLS.

Item 12

The Shopping Center

In a new shopping center, 4 stores are going to be placed on the ground floor. A BARBER SHOP (B), a DISCOUNT STORE (D), a GROCERY STORE (G), and a COFFEE SHOP (C) want to locate there.



One possible way that the stores could be arranged in the 4 locations is BDGC. Which means the BARBER SHOP first, the DISCOUNT STORE next, then the GROCERY STORE and the COFFEE SHOP last.

LIST ALL THE OTHER POSSIBLE WAYS THAT THE STORES CAN BE LINED UP IN THE FOUR LOCATIONS.

INTEGRATED PROCESS SKILLS TEST II

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May 1982

Please make no marks on this test booklet.

1. A football coach thinks his team loses because his players lack strength. He decides to study factors that influence strength. Which of the following variables might the coach study to see if it affects the strength of the players?

   A. Amount of vitamins taken each day.

   B. Amount of lifting exercises done each day.

   C. Amount of time spent doing exercises.

   B. All of the above.

2. A study of auto efficiency is done. The hypothesis tested is that a gasoline additive will increase auto efficiency. Five identical cars each receive the same amount of gasoline but with different amounts of Additive A. They travel the same track until they run out of gasoline. The research team records the number of miles each car travels. How is auto efficiency measured in this study?

   A. The time each car runs out of gasoline.

   B. The distance each car travels.

   C. The amount of gasoline used.

   D. The amount of Additive A used.

3. An auto manufacturer wants to make cars cheaper to operate. They are studying variables that may affect the number of miles per gallon that autos get. Which variable is likely to affect the number of miles per gallon?

   A. Weight of the car.

   B. Size of the motor.

   C. Color of the car.

   D. Both A and B.

4. A class is studying the speed of objects as they fall to the earth. They design an investigation where bags of gravel weighing different amounts will be dropped from the same height. In their investigation which of the following is the hypothesis they would test about the speed of objects falling to earth?

   A. An object will fall faster when it is dropped further.

   B. The higher an object is in the air the faster it will fall.

   C. The larger the pieces of gravel in a bag the faster it will fall.

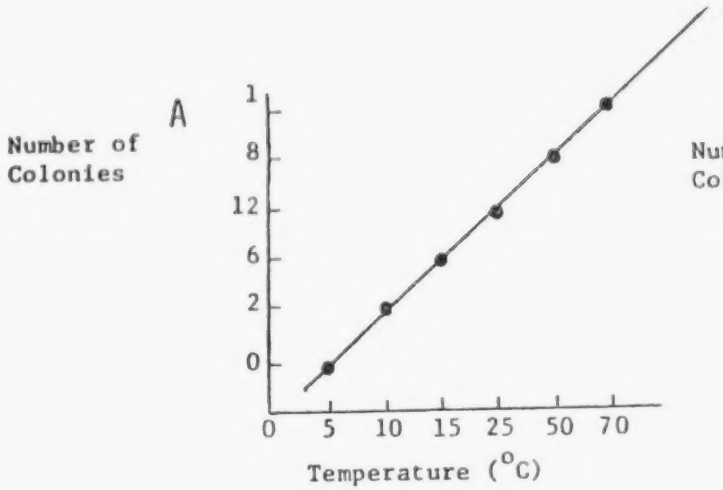
   D. The heavier an object the faster it will fall to the ground.

5. A student in a science class studied the effect of temperature on the growth of bacteria. The student obtained the following data:

Temperature of growth chamber (°C)	Number of bacterial colonies
5	0
10	2
15	6
25	12
50	8
70	1

Which graph correctly represents the data from the experiment?

A



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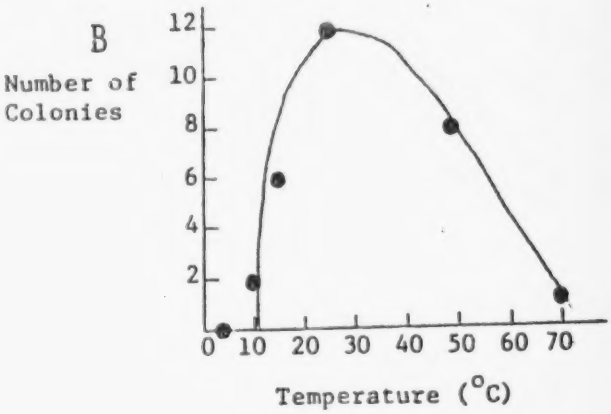

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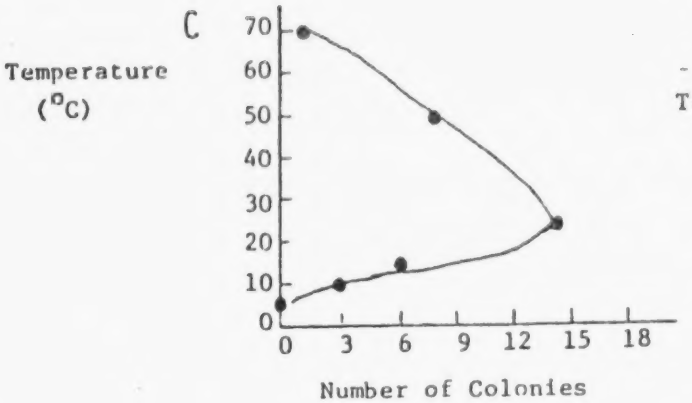
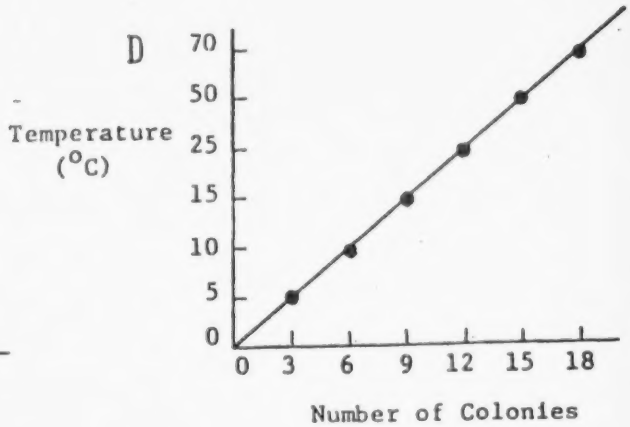


D



6. A police chief is concerned about reducing the speed of autos. He thinks several factors may affect automoblile speed.

   Which of the following is a hypothesis he could test about how fast people drive?

   A. The younger the drivers, the faster they are likely to drive.

   B. The larger the autos involved in an accident, the less likely people are to get hurt.

   C. The more policemen on partol, the fewer the number of auto accidents.

   D. The older the autos, the more accidents they are likely to be in.

7. The effect of wheel width on ease of rolling is being studied by a science class. The class puts wide wheels onto a small cart and lets it roll down an inclined ramp and then across the floor. The investigation is repeated using the same cart but this time fitted with narrow wheels.

   How could the class measure ease of rolling?

   A. Measure the total distance the cart travels.

   B. Measure the angle of the inclined ramp.

   C. Measure the width of each of the two sets of wheels.

   D. Measure the weight of each of the carts.

8. A farmer wonders how he can increase the amount of corn he grows. He plans to study factors that affect the amount of corn produced. Which of these hypotheses could he test?

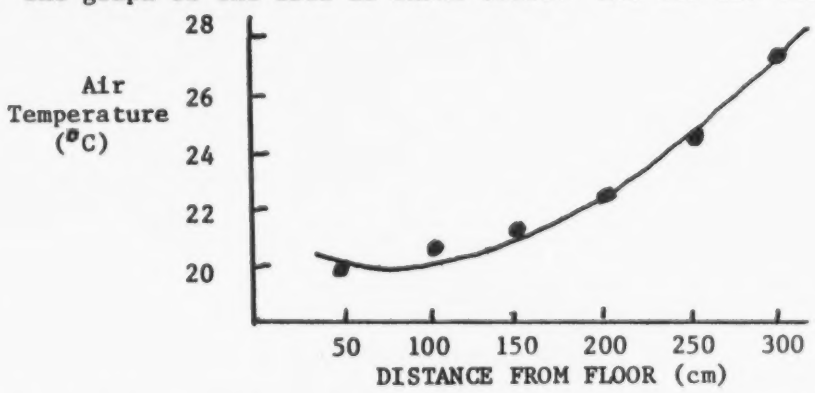
   A. The greater the amount of fertilizer the larger the amount of corn produced.

   B. The greater the amount of corn, the larger the profits for the year.

   C. As the amount of rainfall increases, the more effective the fertilizer.

   D. As the amount of corn produced increases, the cost of production increases.

9. A study is done of the temperature in a room at different distances above the floor. The graph of the data is shown below. How are the variables related?



   A. As distance from the floor increases, air temperature decreases.

   B. As distance from the floor increases, air temperature increases.

   C. An increase in air temperature means a decrease in distance from the floor.

   D. The distance from the floor is not related to air temperature increases.

10. Jim thinks that the more air pressure in a basketball, the higher it will bounce. To investigate this hypothesis he collects several basketballs and an air pump with a pressure guage. How should Jim test his hypothesis?

    A. Bounce basketballs with different amounts of force from the same height.

    B. Bounce basketballs having different air pressures from the same height.

    C. Bounce basketballs having the same air pressure at different angles from the floor.

    D. Bounce basketballs having the same amount of air pressure from different heights.

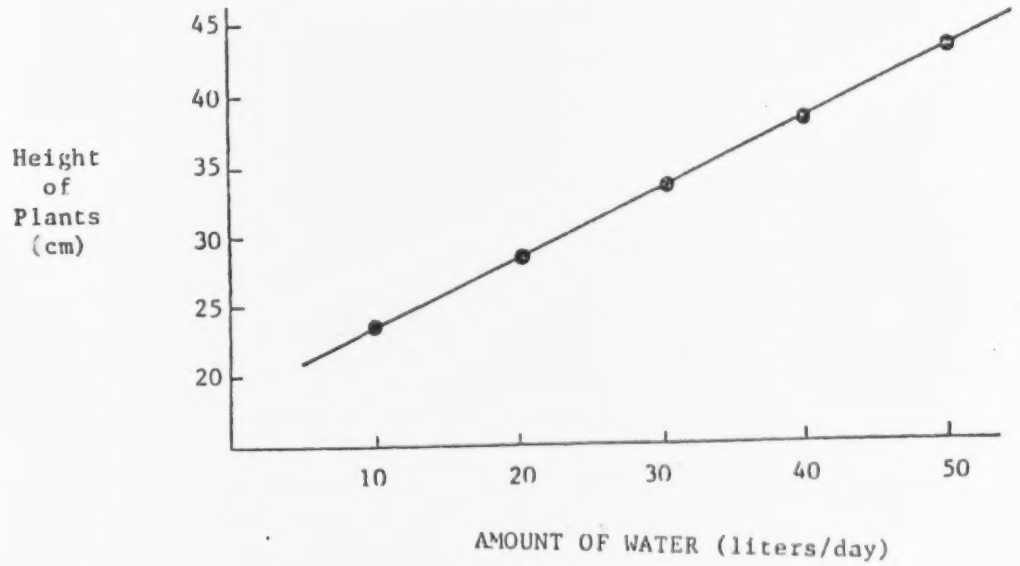
11. A study is being done on the amount of water needed to grow plants. Five small plots are given different amounts of water. After two months the height of the plants is measured. The data are shown in the graph. What is the relationship between the variables?

    A. Increasing the amount of water increases the height of the plants.

    B. Increasing the height of the plants increases the amount of water.

    C. Decreasing the amount of water increases the height of the plants.

    D. Decreasing the height of the plants decreases the amount of water.



Marie wondered if the earth and oceans are heated equally by sunlight. She decided to conduct an investigation. She filled a bucket with dirt and another bucket of the same size with water. She placed them so each bucket recieved the same amount of sunlight. The temperature in each was measured every hour from 8:00 a.m. to 6:00 p.m.

12. Which hypothesis was being tested?

    A. The greater the amount of sunlight, the warmer the soil and water become.

    B. The longer the soil and water are in the sun, the warmer they become.

    C. Different types of material are warmed differently by the sun.

    D. Different amounts of sunlight are received at different times of the day.

13. Which of these variables is controlled in the study?

    A. Kind of water placed in the bucket.

    B. Temperature of the water and soil.

    C. Type of material placed in the buckets.

    D. Amount of time each bucket is in the sun.

14. What was the dependent or responding variable?

    A. Kind of water placed in the bucket.

    B. Temperature of the water and soil.

    C. Type of material placed in the buckets.

    D. Amount of time each bucket is in the sun.

15. What was the independent or manipulated variable?

    A. Kind of water placed in the bucket.

    B. Temperature of the water and soil.

    C. Type of material placed in the bucket.

    D. Amount of time each bucket is in the sun.

16. Susan is studying food production in bean plants. She measures food production by the amount of starch produced. She notes that she can change the amount of light, the amount of carbon diodide, and the amount of water that plants receive. What is a testable hypothesis that Susan could study in this investigation?

A. The more carbon dioxide a bean plant gets the more starch it produces.

B. The more starch a bean plant produces the more light it needs.

C. The more water a bean plant gets the more carbon dioxide it needs.

D. The more light a bean plant receives the more carbon dioxide it will produce.

Joe wanted to find out if the temperature of water affected the amount of sugar that would dissolve in it. He put 50ml. of water into each of four identical jars. He changed the temperatures of the jars of water until he had one at 0°C, one at 50°C, one at 75°C, and one at 95°C. He then dissolved as much sugar as he could in each jar by stirring.

17. What is the hypothesis being tested?

A. The greater the amount of stirring, the greater the amount of sugar dissolved.

B. The greater the amount of sugar dissolved, the sweeter the liquid.

C. The higher the temperature, the greater the amount of sugar dissolved.

D. The greater the amount of water used, the higher the temperature.

18. What is a controlled variable in this study?

A. Amount of sugar dissolved in each jar.

B. Amount of water placed in each jar.

C. Number of jars used to hold water.

D. The temperature of the water.

19. What is the dependent or responding variable?

A. Amount of sugar dissolved in each jar.

B. Amount of water placed in each jar.

C. Number of jars used to hold water.

D. The temperature of the water.

20. What is the independent or manipulated variable?

A. Amount of sugar dissolved in each jar.

B. Amount of water placed in each jar.

C. Number of jars used to hold water.

D. The temperature of the water.

21. A greenhouse manager wants to speed up the production of tomato plants to meet the demands of anxious gardeners. She plants tomato seeds in several trays. Her hypothesis is that the more moisture seeds receive the faster they sprout. How can she test this hypothesis?

    A. Count the number of days it takes seeds receiving different amounts of water to sprout.

    B. Measure the height of the tomato plants a day after each watering.

    C. Measure the amount of water used by plants in different trays.

    D. Count the number of tomato seeds placed in each of the trays.

22. A gardener notices that his squash plants are being attacked by aphids. He needs to get rid of the aphids. His brother tells him that "Aphid-Away" powder is the best insecticide to use. The county agent says "Squash-Saver" spray works best. The gardener selects six squash plants and applies the powder to three and the spray to three. A week later he counts the number of live aphids on each of the plants. How is the effectiveness of the insecticides measured in this study?

    A. Measuring the amount of spray or powder used.

    B. Determining the condition of the plants after spraying or dusting.

    C. Weighing the squash each plant produces.

    D. Counting the number of aphids remaining on the plants.

23. Lisa wants to measure the amount of heat energy a flame will produce in a certain amount of time. A burner will be used to heat a beaker containing a liter of cold water for ten minutes. How will Lisa measure the amount of heat energy produced by the flame?

    A. Note the change in water temperature after ten minutes.

    B. Measure the volume of water after ten minutes.

    C. Measure the temperature of the flame after ten minutes.

    D. Calculate the time it takes for the leter of water to boi.

24. Mark is studying the effect of temperature on the rate that oil flows. His hypothesis is that as the temperature of the oil increases it flows faster. How could he test this hypothesis?

    A. Heat oil to different temperatures and weigh it after it flows out of the can.

    B. Observe the speed at which oil at different temperatures flows down a smooth surface.

    C. Let oil flow down smooth surfaces at different angles and observe its speed.

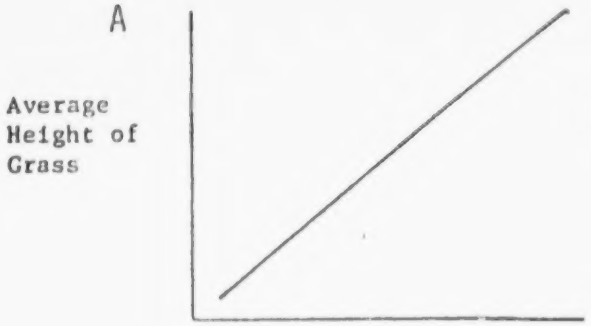
    D. Measure the time it takes for oil of different thicknesses to pour out of the can.

25. A researcher is testing a new fertilizer. Five small fields of the same size are used. Each field receives a different amount of fertilizer. One month later the average height of the grass in each plot is measured. The measurements are shown in the table below.

Amount of Fertilizer (kg)	Average Height of Grass (cm)
10	7
30	10
50	12
80	14
100	12

Which graph represents the data in the table?

A



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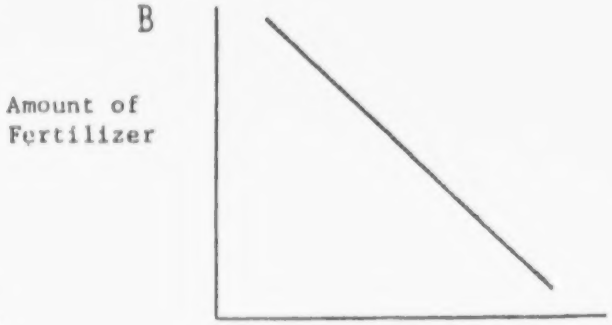

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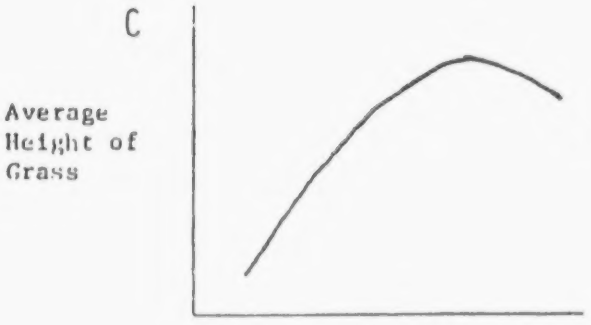

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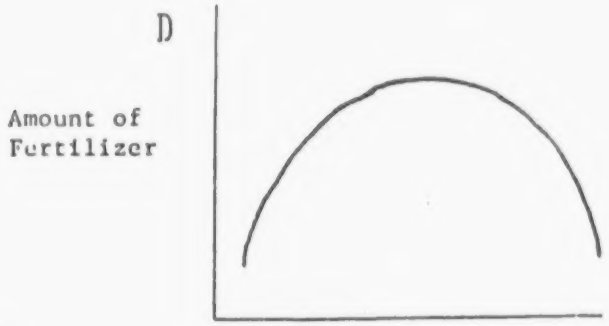


26. A biologist tests this hypothesis: the greater the amount of vitamins given to rats the faster they will grow. How can the biologist measure how fast rats will grow?

A. Measure the speed of the rats.

B. Measure the amount of exercise the rats receive.

C. Weigh the rats every day.

D. Weigh the amount of vitamins the rats will eat.

27. Some students are considering variables that might affect the time it takes for sugar to dissolve in water. They identify the temperature of the water, the amount of sugar and the amount of water as variables to consider. What is a hypothesis the students could test about the time it takes for sugar to dissolve in water?

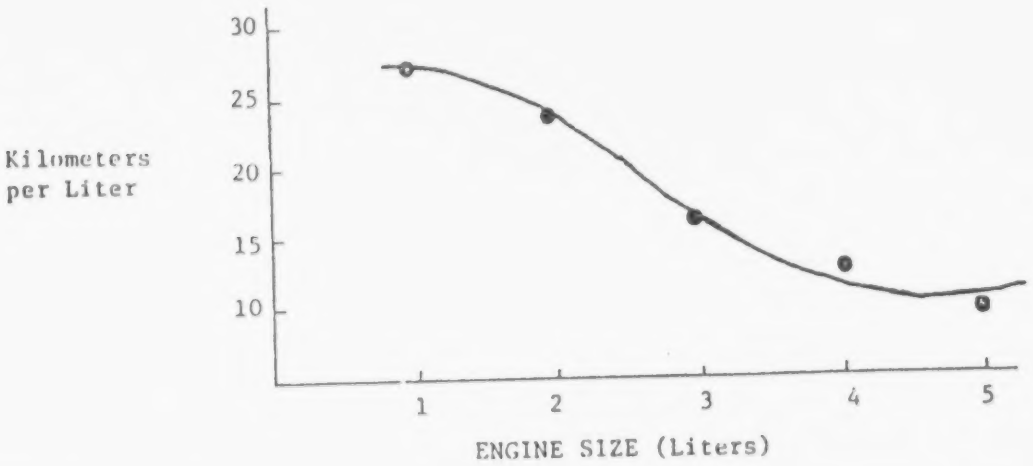
A. The larger the amount of sugar the more water required to dissolve it.

B. The colder the water the faster it has to be stirred to dissolve.

C. The warmer the water the more sugar that will dissolve.

D. The warmer the water the more time it takes the sugar to dissolve.

28. A consumer group measures the miles per gallon cars get with different size engines. The results are as follows:



Which of the following describes the relationship between the variables?

A. The larger the engine the more miles per gallon the car gets.

B. The fewer miles per gallon the car gets the smaller the engine.

C. The smaller the engine the more miles per gallon a car gets.

D. The more miles per gallon for a car the larger the engine.

A study was done to see if leaves added to soil had an effect on tomato production. Tomato plants were grown in four large tubs. Each tub had the same kind and amount of soil. One tub had 15 kg of rotted leaves mixed in the soil and a second had 10 kg. A third tub had 5 kg and the fourth had no leaves added. Each tub was kept in the sun and watered the same amount. The number of kilograms of tomatoes produced in each tub was recorded.

29. What is the hypothesis being tested?

    A. The greater the amount of sunshine, the greater the amount of tomatoes produced.

    B. The larger the tub, the greater the amount of leaves added.

    C. The greater the amount of water added, the faster the leaves rotted in the tubs.

    D. The greater the amount of leaves added, the greater the amount of tomatoes produced.

30. What is a controlled variable in this study?

    A. Amount of tomatoes produced in each tub.

    B. Amount of leaves added to the tubs.

    C. Amount of soil in each tub.

    D. Number of tubs receiving rotted leaves.

31. What is the dependent or responding variable?

    A. Amount of tomatoes produced in each tub.

    B. Amount of leaves added to the tubs.

    C. Amount of soil in each tub.

    D. Number of tubs receiving rotted leaves.

32. What is the independent or manipulated variable?

    A. Amount of tomatoes produced in each tub.

    B. Amount of leaves added to the tubs.

    C. Amount of soil in each tub.

    D. Number of tubs receiving rotted leaves.

33. A student is investigating the lifting ability of magnets. He has several magnets of different sizes and shapes. For each magnet, the student weighs the amount of iron filings it picks up. How is the lifting ability of a magnet defined in the experiment?

    A. The size of the magnet in use.

    B. The weight of the magnet picking up things.

    C. The shape of the magnet in use.

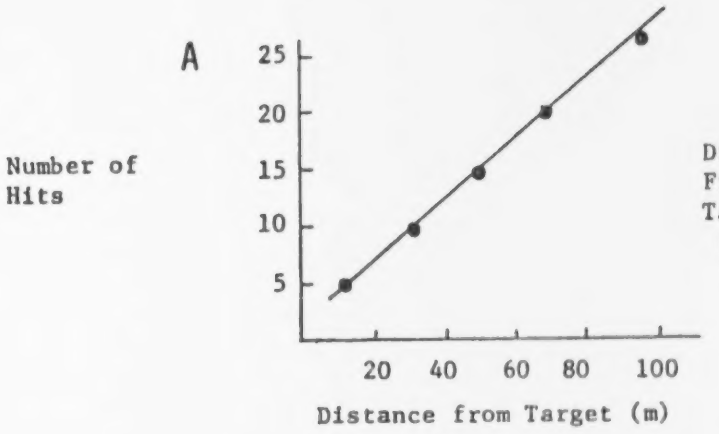
    D. The weight of the iron filings picked up.

34. Twenty-five shots are fired at a target from several distances. The table below shows the number of "hits" in 25 shots at each distance.

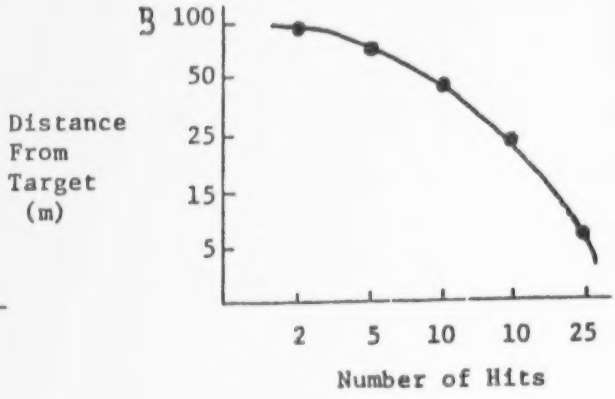
Distance from Target (m)	Number of Hits
5	25
15	10
25	10
50	5
100	2

Which graph best represents the data?

A



B



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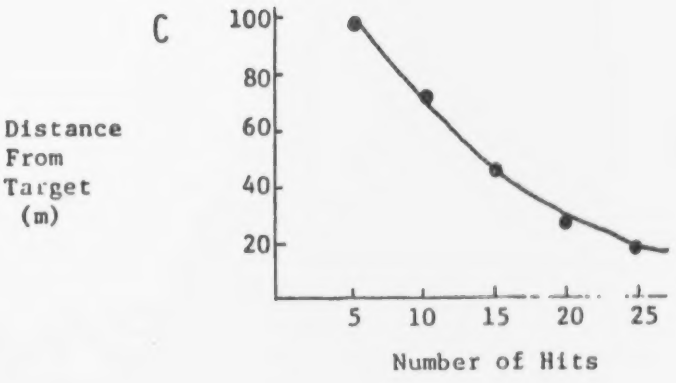

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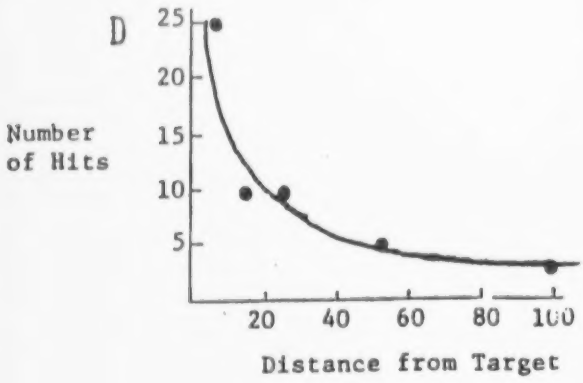

35. Ann has an aquarium in which she keeps goldfish. She notices that the fish are very active sometimes but not at others. She wonders what affects the activity of the fish. What is a hypothesis she could test about factors that affect the activity of the fish?

A. The more you feed fish, the larger the fish become.

B. The more active the fish, the more food they need.

C. The more oxygen in the water, the larger the fish become.

D. The more light on the acquarium, the more active the fish.

36. Mr. Bixby has an all electric house and is concerned about his electric bill. He decides to study factors that affect how much electrical energy he uses. Which variable might influence the amount of electrical energy used?

A. The amount of television the family watches.

B. The location of the electric meter.

C. The number of baths taken by family members.

D. A and C.

SCIENCE ATTITUDE SCALE

The survey consists of a number of statements designed to sample your opinions about science. There are no right or wrong answers. What is wanted is your own individual feeling about the statements. Please read each statement carefully and decide how YOU feel about it.

Directions: Please circle the RESPONSE which best represents your opinion to the following statements in the following manner:

If you strongly disagree, circle "SD" ..... SD D U A SA
If you disagree, circle "D" ..... SD D U A SA
If you are undecided or uncertain, circle "U" ..... SD D U A SA
If you strongly agree, circle "SA" ..... SD D U A SA

1. I am always under a terrible strain in a science class. SD D U A SA
2. I do not like science and it scares me to have to take it. SD D U A SA
3. Science is very interesting to me and I enjoy science courses. SD D U A SA
4. Science is fascinating and fun. SD D U A SA
5. Science makes me feel secure and, at the same time, it is stimulating. SD D U A SA
6. My mind goes blank and I am unable to think clearly when working in science. SD D U A SA
7. I feel a sense of insecurity when attempting science. SD D U A SA
8. Science makes me feel uncomfortable, restless, irritable, and impatient. SD D U A SA
9. The feeling that I have toward science is a good feeling. SD D U A SA
10. Science makes me feel as though I'm lost in a jungle of numbers and can't find my way out. SD D U A SA
11. Science is something which I enjoy a great deal. SD D U A SA
12. When I hear the word science, I have a feeling of dislike. SD D U A SA
13. I approach science with a feeling of hesitation, resulting from a fear of not being able to do science. SD D U A SA
14. I really like science. SD D U A SA
15. Science is a course in school which I have always enjoyed studying. SD D U A SA
16. It makes me nervous to even think about having to do a science experiment. SD D U A SA
17. I have never liked science and it is my most dreaded subject. SD D U A SA
18. I am happier in a science class than in any other class. SD D U A SA
19. I feel at ease in science and I like it very much. SD D U A SA
20. I feel a definite positive reaction to science; it's enjoyable. SD D U A SA

STUDENT QUESTIONNAIRE

The purpose of this questionnaire is to learn more about the various activities that students participate in and out of school. Please try to respond to each of the statements as fairly and quickly as possible. Thank you for assisting us with this important research.

Name of School: _____ Age: ___ ___ Grade: _____ Sex: 1-Male, 2-Female (Circle 1 or 2)
yr. mo.

I. Please read through each of the following "school activities" and "out-of-school activities" and indicate how frequently you have been involved with them during the past two years using the following key: 1 = often, 2 = sometimes, 3 = never. Please indicate by placing an X in the appropriate space.

ACTIVITIES	Frequency of Activities					
	School			Out-of-School		
	1 Often	2 Some-times	3 Never	1 Often	2 Some-times	3 Never
1. Visits to science museums, science centers						
2. Visits to planetarium						
3. Visits to the libraries to read science books, magazines, periodicals, etc.						
4. Visits to marine science centers						
5. Visits to the zoo						
6. Visits to botanical gardens						
7. Receives private tutoring in science and/or mathematics						
8. Take part in camping, fishing, or hiking						
9. Have an experience in watching birds						
10. Have an experience in insect collecting						
11. Have an experience in gathering plants, leaves and flowers						
12. Have an experience in gathering rocks and fossils						
13. Observe stars and moon through telescope						
14. Have an experience in building model ships, cars, airplanes, or dollhouse						
15. Have an experience in reporting your findings to your friends						

ACTIVITIES	Frequency of Activities						
	School				Out-of-School		
	1 Often	2 Some-times	3 Never		1 Often	2 Some-times	3 Never
16. Take part in science fairs and contests							
17. Visit geological places, e.g. strata, volcanoes, seashores							
18. Take part in science club activities							
19. Participate in special activities of science centers or museums							
20. Participate in boy or girl scouting							
21. Watch TV science programs or listen to radio science programs							
22. Have experience in using microscopes							
23. Have experience in making scientific experiments with your own instruments							
24. Have experience in using microcomputers							
25. Have experience in caring for birds, rabbits, cats, dogs, or hamsters							
26. Have experience in caring for fish							
27. Have experience in examining and repairing electrical appliances							
28. Have experience in using woodwork or metal work tools, e.g. pliers, saw, planes, screwdrivers, etc.							
29. Have experience in raising your favorite plants							

U.S.-JAPAN COOPERATIVE RESEARCH PROJECT

East Carolina University
Greenville, N. C. USA

Hiroshima University
Hiroshima, Japan

The aim of this questionnaire is to find ways of improving science education in Japan and the United States. Please respond to the quesions as accurately as possible. All information will be strictly confidential.

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1. Please circle the appropriate response.

   Sex: Male Female

2. Age: _____

3. Teaching Experience: ____ Years

4. List the number of science subjects and classes you are presently

Subject	No. of Classes
_____	_____
_____	_____
_____	_____

5. Type of certification: Undergraduate ___ Graduate ___ Other ___

   A. Please rank the following subjects using: 1=highest, 2=high, 3=low, in terms of the amount of content taken at college/university.

Subject	Ranking (Circle)		
(1) Physics	1	2	3
(2) Chemistry	1	2	3
(3) Biology	1	2	3
(4) Earth Science	1	2	3
(5) Applied Science	1	2	3
(6) Others	1	2	3

   B. Certification: Please list your areas of certification.

   _____

_____

_____

_____

_____

6. Please circle the number in the table below that indicates how often you use the items listed in teaching science.

Key: 1 = very frequent
2 = frequent
3 = sometimes
4 = rare
5 = never or not applicable

		Circle				
A.	Teaching Aids					
(1)	Textbook	1	2	3	4	5
(2)	Experimental worksheet	1	2	3	4	5
(3)	Pupil activity workbook	1	2	3	4	5
(4)	TV programs	1	2	3	4	5
(5)	Other AV aids (films, overhead projectors, etc.)	1	2	3	4	5
(6)	Science reading materials	1	2	3	4	5
(7)	Models, charts	1	2	3	4	5
(8)	Materials and equipment	1	2	3	4	5
(9)	Microcomputers	1	2	3	4	5
B.	Teaching and Learning Activities					
(1)	Lecture/discussion	1	2	3	4	5
(2)	Teachers demonstratin	1	2	3	4	5
(3)	Small group discussion	1	2	3	4	5
(4)	Self-paced activities	1	2	3	4	5
(5)	Group activities	1	2	3	4	5
(6)	Laboratory activities	1	2	3	4	5

C. Teaching and Learning Facility

(1)	Laboratory	1	2	3	4	5
(2)	Classroom	1	2	3	4	5
(3)	Lab/classroom combination	1	2	3	4	5
(4)	School grounds	1	2	3	4	5
(5)	Outdoor study areas	1	2	3	4	5
(6)	Science trips away from school	1	2	3	4	5
(7)	Field trips to science centers, museums, etc.	1	2	3	4	5
(8)	Field trips to parks and natural areas	1	2	3	4	5

D. Evaluation

(1)	Paper/pencil test	1	2	3	4	5
(2)	Short answer tests (multiple choice, true/false, etc.)	1	2	3	4	5
(3)	Essay tests	1	2	3	4	5
(4)	Interview	1	2	3	4	5
(5)	Observation of behavior	1	2	3	4	5
(6)	Reports (written or oral)	1	2	3	4	5
(7)	Student projects	1	2	3	4	5
(8)	How often do you improvise teaching aids for your class activities.	1	2	3	4	5
(9)	How often do you design your own evaluation techniques for your class.	1	2	3	4	5
(10)	How often do you use evaluation results to help your pupils gain further understanding of science subjects.	1	2	3	4	5
(11)	How often do you use evaluation results to modify your teaching plans.	1	2	3	4	5

7. In-service Programs/Workshops Attended:

A. Have you participated in science in-service program/workshop programs within the last 3 years.

Yes____ No ___

B. If Yes, pleae indicate the name of sponsors:

University ____

LEA Workshp ____

State Department Workshop ____

C. If Yes, what kind of activities did you undertake in the workshop/in-service program?

_____

_____

_____

8. Teacher Conferences:

A. Have you participated in state or national science teachers conferences within the last 3 years?

Yes ____ No ____

Number of meetings attended ____

B. List science associations to which you belong:

_____

_____

_____

9. Science Literature

A. How often do you read science related literature e.g. magazines, periodicals, specialized science books?

Very frequent ____ Sometime ____ Rare____

B. Please give the name(s) of the monthly magazines you read:

_____

_____

_____

_____

10. Science Education Literature

A. How often do you read science education related literature, e.g. magazines, periodicals, and specialized science education books?

Very frequent ____ Sometime ____ Rare ____

B. Please give the name(s) of the monthly magazines you read:

_____

_____

_____